Build this airplane for under $10,000 >>>
(See how, page 40)

CSI Guadalcanal: Crash Investigation

AIR&SPACE Smithsonian

Secrets from the Winner's Circle

THE SCIENCE OF AIR RACING

Mission: Crash Into the Moon

The Act That Changed Airshows Forever

What the Voodoo Did

(P. 60)

Air Racing Champion Mary Dilda

JANUARY 2007

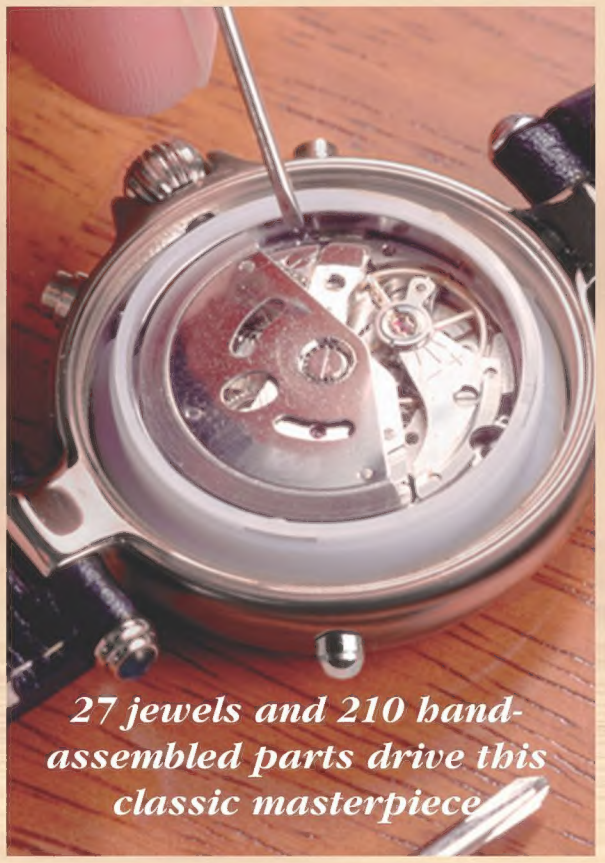
World's Most Valuable Timepiece Disappears

Back in 1933, the single most important watch ever built was engineered for a quiet millionaire collector named Henry Graves. It took over three years and the most advanced horological technique to create the multifunction masterpiece. This one-of-a-kind watch was to become the most coveted piece in the collection of the Museum of Time near Chicago. Recently this ultra-rare innovation was auctioned off for the record price of $11,030,000 by Sotheby's to a secretive anonymous collector. Now the watch is locked away in a private vault in an unknown location. We believe that a classic like this should be available to true watch aficionados, so Stauer replicated the exact Graves design in the limited edition Graves '33.

The antique enameled face and Bruguet hands are true to the original. But the real beauty of this watch is on the inside. We replicated an extremely complicated early automatic movement with 27 jewels and seven hands. There are over 210 individual parts that are assembled entirely by hand and then tested for over 15 days on Swiss calibrators to ensure accuracy. The watches are then reinspected in the United States upon their arrival.

What makes rare watches rare?

Business Week states it best…"It's the complications that can have the biggest impact on price." (*Business Week, July, 2003*). The four interior complications on our Graves™ watch display the month, day, date and the 24 hour clock graphically depicts the sun and the moon. The innovative engine for this timepiece is powered by the movement of the body as the automatic rotor winds the mainspring. It never needs batteries and never needs to be manually wound. The precision crafted gears are "lubricated" by 27 rubies that give the hands a smooth sweeping movement. And the watch is tough enough to stay water resistant to 5 atmospheres. The movement is covered by a 2-year warranty.



The face of the original 1930 s Graves timepiece from the Museum of Time.

Not only have we emulated this stunning watch of the 1930s but just as surprising, we've been able to build this luxury timepiece for a spectacular price. Many fine 27-jewel automatics that are on the market today are usually priced well over $2,000 dollars, but you can enter the rarified world of fine watch collecting for under $100. You can now wear a millionaire's watch but still keep your millions in your vest pocket. Try the handsome Graves '33 timepiece risk free for 30 days. If you are not thrilled with the quality and design, send it back for a full refund of the purchase price.

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(ACTUAL GAME SCREEN SHOT)

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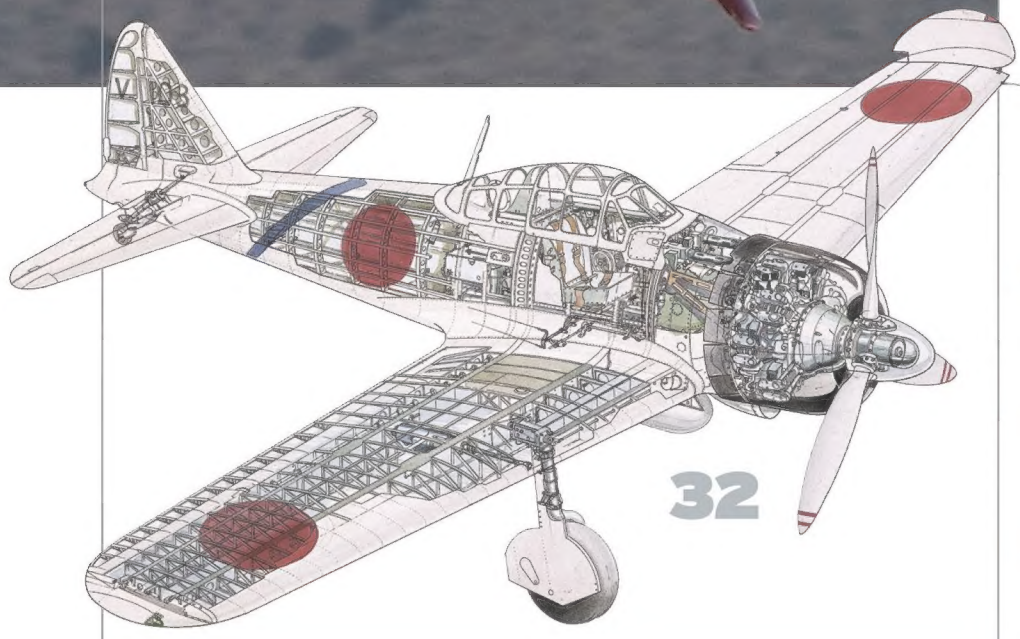
December 2006/January 2007 | Vol. 21, No. 5

AIR&SPACE Smithsonian

ON THE COVER That 600-horsepower Pratt & Whitney Wasp radial gives the T-6 Texan its get-up-and-go, but race pilot Mary Dilda adds the finesse to win the gold. Dilda has won three Reno air races (see p. 22) and performs at airshows in the *Two of Hearts*. Photograph by Chad Slattery.



Features

Departments

On the Web www.airspacemag.com
ORIGINAL WEB-ONLY FEATURES are now on our redesigned Web site, along with extras to supplement articles in this issue. A new feature, "Need to Know," provides answers from experts to aviation and space questions (e-mail *pappalardoj@si.edu* to pose a question).

What was Canon thinking when they gave aviation photographers the ability to shoot with virtually no turbulence?

Exactly what you were thinking.

As an aviation photographer, you don't really ask for much: a clear day, beautiful planes and a smooth ride. And while Canon can't promise you the first two, they really deliver on the last one, thanks to their superb Image Stabilizer technology. By coupling the 8.2-megapixel EOS 30D or the new 10.1-megapixel EOS Digital Rebel XTi with a lens like the EF 70-300mm f/4.5-5.6 DO IS USM, you not only smooth out the vibrations of the plane, you can slow the shutter speed down enough to get that spectacular prop blur. And both cameras feature Canon's DiG!C II Image Processor, so your images are always clear and beautiful. Maybe Canon *can* do something about those first two things after all.

Canon

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History in the Filmmaking

AMONG THE MOST EVOCATIVE resources in the National Air and Space Museum, the motion pictures in our archive show what it was like to be there when history was made. Newsreel footage of the beginning of Charles Lindbergh's transatlantic flight, for example, shows a small crowd that has gathered before dawn to see the takeoff. Watching the film, we can imagine we're standing with the spectators. We can see how heavy the airplane is: how slow it is to accelerate and how deeply it settles on its landing gear as it bounces along the runway and splashes up water from puddles.

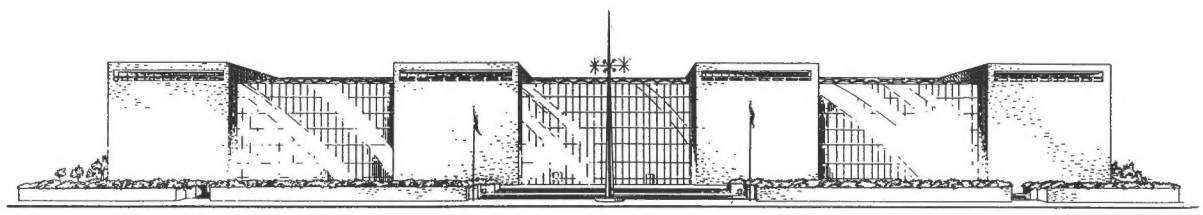
Besides documentaries of historic events, the collection includes other types of motion pictures. Instructional films tell the viewer how to handle the Bullpup missile, preflight a Lockheed T-33 trainer, or follow emergency procedures in a Republic F-105. There is footage of interviews: The record-setter and showman Roscoe Turner describes his career as a series of aviation milestones. Space shuttle crews in post-flight press conferences discuss their missions. And more mundane promotional films highlight industrial processes or the introduction of an airliner into service.

Some of the most remarkable films in the collection are home movies. Those shot by inventor Grover Loening in the mid-1920s show the first flight of a Loening amphibian, followed by scenes of Loening, his wife, and their friends relaxing at the Long Island Country Club. In another set of home movies, an American family flies home from a 1936 trip to Europe on the zeppelin *Hindenburg*.

The collection of motion pictures began as a resource for our curators, but today it can be used by other researchers as well. Because the films are fragile and must be stored in a cold, dry environment, viewing is possible only by appointment. Most of the films are on acetate-base safety film. As it ages, the acetate deteriorates, shrinks, and becomes brittle. It also forms acetic acid—vinegar. By the time a film starts to smell like vinegar, it has shrunken so much it can no longer be safely run through a projector. In addition, as color film ages, the dyes that make up the image fade at different rates. This explains why some old films have a purplish cast. Deterioration can be slowed by cooling the film. The temperature and humidity level at which the Museum keeps the collection will help the films remain stable for many more decades.

Some films in the archive are closely tied to the artifacts on display in the Museum. The famous aerobatic pilot Art Scholl developed camera mounts for his DHC-1A deHavilland Super Chipmunk aerobatic airplane, and the Museum has both the airplane and the cameras. Thanks to the generosity of Scholl's family, the Museum also has the film those cameras shot.

J.R. DAILEY IS THE DIRECTOR OF THE NATIONAL AIR AND SPACE MUSEUM.



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QC2 headphones (left). New QC3 headphones (right).

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FOR TRAVEL WORK HOME

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Letters

WRITE TO US

A Twisted Past

"No one's quite sure where or when the corkscrew landing approach originated," says the author of "Landing in Baghdad" (Oct./Nov. 2006). During flight training in World War II, we were taught the Overhead Approach, which was very similar to what your article described, the only difference being that the angle of bank was less. The intent was to be able to land at the airport without first going through the downwind, base, and final-approach legs.

Lt. Col. Jack L. Miller
U.S. Air Force (ret.)
Fort Collins, Colorado

In 1958, while flying my AD-5N Skyraider from the *Hornet*, I had two emergencies that required that I land on the carrier dead-stick, and I used just the approach your story describes. Having no power for a wave-off, I was fortunate to catch a wire both times.

Although your article reports that some airline captains call it boring, at the time the approach held plenty of "pucker factor" for me!

Bill Happersett
Walnut Creek, California

While serving in Vietnam, I flew the old, reliable C-1A delivery aircraft out of Da Nang. We brought mail, parts, and personnel to the four attack aircraft carriers on Yankee Station in the Tonkin Gulf. With Viet Cong troops hidden close to the field boundary, the tower was always warning, "Small arms fire reported on final." Most approaches to landing were made from the sea, with a sharp 90-degree turn to enter downwind. We dropped gear and deployed full flaps, as your article describes, but maintained 1,500 feet until the runway passed under the nose. At that point, we closed the throttles and pushed over for a steep gliding approach to the runway. As we pulled the nose up, we added a little burst of power to cushion the touchdown. All post-flight inspections included a walkaround in order to check for bullet damage.

Way back, that circular approach was called the Graveyard Spiral. It was named by the old mail plane pilots who, without instruments, would fly into clouds and start to lose altitude. Not knowing that they had dropped a wing, they would pull back on the stick to raise the nose, but this only tightened the turn and increased the rate of descent. While trying to figure it out, many flew right into the ground.

Lt. Cmdr. Robert A. Shaver
U.S. Navy (ret.)
North Kingstown, Rhode Island

Bernie Fisher, the first living U.S. Air Force recipient of the Medal of Honor, used the maneuver. In *Beyond the Call of Duty*, he tells of having an engine failure in an F-4 in the early 1960s. He tried the maneuver, and the successful experience helped him in a second dead-stick landing less than a year later.

William Aldridge
Grantsville, Utah

Adventures in Flameland

In four years in the Air Force during the Korean "police action," the only flameouts I ever encountered happened on the ground ("Flameout," Aug./Sept. 2006). These occurred in the F-89's J-35 engines. The air intakes on the F-89 were very close to the ground and picked up every foreign object the aircraft went over.

I was also very familiar with the F-94B and -C. The latter was powered by the Pratt & Whitney J-48, which had a very powerful ignition system. If a flameout occurred, the procedure was to engage the starter and flip the emergency ignition switch. If the ignition would not start the engine, the pilot could pull a handle that would fire two shotgun shells. The shells were loaded with gunpowder and magnesium, which would create an intense flame to relight the fires.

Rand D. Williams
Poland, Ohio

Brains Conquer Beauty

Scientists break code to create impeccably brilliant cut jewelry with even more clarity and color dispersion than mined diamonds.

There is little doubt that a natural mined diamond of top quality is one of the world's most magnificent gems. It is much coveted for its exquisite beauty, but the simple truth is that diamonds are just compressed crystallized carbon. The laboratories at Diamond*Aura* were created with one mission in mind: *Create brilliant cut DiamondAura jewelry in precious metal settings that allow everyone to experience jewelry with superb clarity and large carat weight.*

Perfection from the laboratory. We named our brilliant cut collection Diamond*Aura*, because simply said, "they dazzle just like natural diamonds but without the outrageous cost." Our Diamond*Auras* are an absolute marvel of modern gemological science. We insisted that our scientists reproduce the look of a loupe-clean diamond in the laboratory, and would not accept any result other than perfection. We will not bore you with the incredible details of the scientific process, but will only say that it involves the use of rare minerals heated to an incredibly high temperature of over 5000°F. This can only be accomplished inside some very modern and expensive laboratory equipment. After several additional steps, scientists finally created a clear faultless marvel that looks even better than the vast majority of mined diamonds. Noted jewelry expert Steven Rozensky said, "The color and clarity of Diamond*Aura* rivals that of a flawless D colored diamond". Of course, flawless diamonds sell for in excess of $50,000 a carat, so they are priced out of reach. With precious metal settings and sizes exceeding 1 carat, the visual effects are breathtaking!

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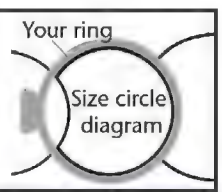

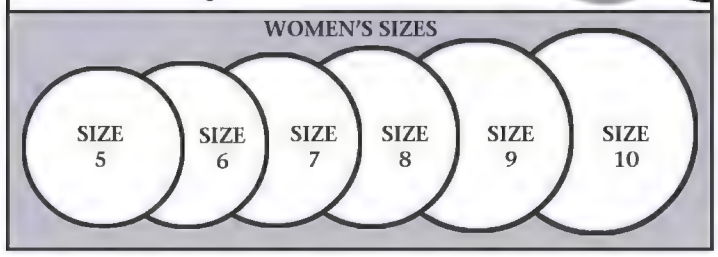

Stormbird Watchers

In "Stormbird" (Oct./Nov. 2006) Douglas Gantenbein made the common assertion that sweeping the Me 262's wings improved its aerodynamic performance. Actually, the 262 was intended to have straight wings, and only when the jet engines made the craft much more tail-heavy than piston units did Messerschmitt sweep the outer wings enough to shift the axis of lift back and thus rebalance the plane, avoiding a major redesign. That is why the fore-and-aft framing and paneling of the outer wings is not in line with the airflow. The slight sweep back made no significant difference to level speed, although it did improve transonic dive performance a little.

The 262 had two serious design flaws. First, the wings were too small. They had the same area as those of the much lighter Mustang and Spitfire, and were much smaller than the similarly massive P-47 Thunderbolt. With big wings, the Stormbird would have still been very fast, but could have turned with the Allied machines, a capacity that would have made it a far more dangerous opponent.

The second flaw was the engine. Had the Germans put their effort into the three-row, 21-cylinder BMW radial, which put out about 3,000 horsepower, and fitted it in a Focke Wulf Fw 190 with enlarged wings, the result would have been a machine capable of 500 mph but without the difficulties of the new jets. Such an aircraft could have been a real headache for the Allies before, during, and after D-Day.

Gregory Paul
Baltimore, Maryland

The caption for the photograph on page 24 describes a group of Me 262s

»» A NEWLY COMPLETED REPLICA of the Me 262 flies over Washington's Puget Sound (above) with a Consolidated B-24 Liberator bomber, a contemporary of the original jet fighter. Below: The original's prototype roared off a German runway 65 years ago.

"as they taxi for takeoff." During taxi, it's best to have a pilot in the cockpit, and to remove the wheel chocks.

Steven Davis
San Diego, California

As the donor of *Vera* (or "White 35"), the original airframe serving as the template for the Me 262 Project, I was disappointed to find that the sidebar "See the Me 262" did not mention our museum. Now restored, *Vera* is the only two-seat Me 262 in North America on public display.

Susan Halteman, Curator
The Harold F. Pitcairn Wings of Freedom Museum
Willow Grove, Pennsylvania

A Disposable Tailhook?

"Did We Forget Something on the Checklist?..." (Soundings, Oct./Nov. 2006) states that "an Air Force tailhook is for one-time use only." I have been a crew chief on the F-15 for the last 18 years, and in that time, I have had to replace a tailhook only two or maybe three times, because it was damaged.

It is true that, as the article states, the tailhooks on Air Force fighters are designed for emergency operations, but we also use them for holding an aircraft on the ground during high-power and afterburner engine runs.

Bryan Jones
Niceville, Florida

The Electra's Tragic Flaw

Daniel Ford's reply to a letter about Eddie Rickenbacker (Letters, Oct./Nov. 2006) says that the Electra "suffered from wing flutter." As a copilot for a major airline in the early 1960s, I flew in the first Electras. My recollection is that the problem was a weakness in the engine mounts. Aerodynamic forces in flight would displace one or more engines out of the line of thrust, and this caused a harmonic to form in the wing spars, which in turn resulted in the wings breaking at the joint with the fuselage.

Paul A. Ludwig
Seattle, Washington

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When Sparrowhawks Were Ballast

In an attempt to maintain altitude, the crew of the *Macon* tried to lighten its load by dumping the dirigible's four airplanes. But the airship's extreme angle of descent caused the aircraft's deployment mechanisms to jam, and the Sparrowhawks went down with the ship, settling in about 1,500 feet of water.

<<< **CHRIS GRECH FONDLY RECALLS** the 1990 expedition that first discovered the wreck of the USS *Macon*. "We've got planes," someone said, referring to the sight of four Curtiss F9C-2 Sparrowhawk biplanes the *Macon* carried in its belly and which now rest upright on the Pacific Ocean floor, along with the rest of the airship. "We'd made a couple of unsuccessful trips looking for the *Macon*, and our work had finally paid off," Grech says of the missions, which were undertaken by his employer, the Monterey Bay Aquarium Research Institute, in conjunction with the U.S. Navy.

Literally a flying aircraft carrier, the *Macon* was the last of the U.S. Navy's dirigibles. It crashed off the Big Sur coast in 1935 after its tail section suffered a catastrophic structural failure during a squall. In an attempt to maintain altitude, the crew tried to lighten its load by dumping the dirigible's four airplanes. But the airship's extreme angle of descent caused the aircraft's deployment mechanisms to jam, and the Sparrowhawks went down with the ship in about 1,500 feet of water.

Grech, the MBARI's co-principal investigator for the wreck, recently returned to the site in the MBARI's *Western Flyer* research vessel. The expedition was a collaboration sponsored by MBARI, the National Oceanic and Atmospheric Administration's Marine Sanctuary Program, and Stanford University to make a high-resolution photo mosaic of the *Macon*'s debris field. The mosaic will provide NOAA with the data necessary to propose that the wreck be added to the National Register of Historic Places.

Additionally, an understanding of the wreck's dispersal area and rate of deterioration will help in discussions of how to preserve the site and even to plan potential recovery. "The *Macon* is the last intact airship site—not to mention it has biplanes on it," Grech says. "There are no other airships like this in the world. All the German airships are gone, and the *Akron* [the *Macon*'s sister ship, which crashed off the coast of New Jersey in 1933] is too shallow and has been disturbed."

It's up to the Navy and the federal government to figure out what to do with the *Macon*, but Grech and MBARI are standing by to assist in any preservation or recovery.

"If you don't do anything, the *Macon* is just going to go away in 20 years," Grech says. "Maybe we can teach the next generation of rigid airships something."

JOHN J. GEOGHEGAN III

DAVID LEININGER (2)

"We Are the Champions, We Are the Champions..."

>>> ALAN BUCHNER HEADS HOME to Fresno, California, in the 1932 Waco QDC (above) that won the Orville and Wilbur Wright Trophy at the National Aviation Heritage Western Regional competition, held at the Reno National Championship Air Races last September. Buchner found the Waco in a barn in Merced, California, and later learned that his father had flown it in his charter service. Buchner spent 15 years bringing the QDC up to speed. Frank Schelling's 1918 Curtiss JN-4H (right) wafts over the Napa, California countryside after capturing the 2006 Grand Champion title as well as the People's Choice award. The Heritage Invitational is sponsored by Rolls-Royce, the National Air and Space Museum, and the National Aviation Hall of Fame.

Phantom 550's New Haunt

>>> FOR THE PAST 15 YEARS, retired Air Force Brigadier General Daniel Cherry and a group of friends have been rising early and going for a fast-paced three-mile walk in their hometown, Bowling Green, Kentucky. "Then we end up at McDonald's, drinking coffee and solving the world's problems," says Cherry.

In 2004, they took a field trip to the National Museum of the United States Air Force in Dayton, Ohio. Cherry and his buddies were given a private tour and told that a McDonnell Douglas F-4 Phantom might soon be acquired from a nearby Veterans of Foreign Wars outpost, "and that it would have some significance to the people of Kentucky," says Cherry. The guide had no idea that the Phantom to which he was referring was once flown by Cherry himself. "He just mentioned it in passing. But I knew what he was talking about."

Cherry reported to the 13th Tactical Fighter Squadron at Udorn, Thailand, in June 1971 and flew 185 combat missions as part of the Vietnam War's Operation Linebacker. When his F-4 was retired in 1990, it went to the Air Force Reserves at Ohio's Wright-Patterson Air Force Base. The VFW post in Enon, a suburb south of Dayton, acquired the airplane that year and told Cherry the group was going to display it. The Phantom had been there ever since.

On the drive home, Cherry and his friends discussed the idea of getting the Phantom to Bowling Green for restoration and display. Cherry consulted a friend, Ray Buckberry, a history buff who had been researching Kentucky aviators. "None of these stories have been told," says Cherry. "Younger generations don't know these people." So he and Buckberry came up with Aviation Heritage Park. "We would use the Phantom as our first artifact and centerpiece," he says. "That made me feel like we had a broader purpose than simply 'Save Dan Cherry's airplane.'"

In the fall of 2005, the VFW released the Phantom to Aviation Heritage Park Inc., and after undergoing a restoration, the airplane was unveiled last July. "We're not calling ourselves a museum because we don't think of ourselves that way," says Cherry. "What makes us unique is that every [aircraft] displayed will have a real story about a real person connected to our state."

BETTINA H. CHAVANNE

JOHN FLECK

Dan Cherry displays a photo of himself and his Phantom in their salad days while his recently restored F-4 watches his six.

"...and the Wright Model B is out in front by a skid..."

>>> VISITORS AT DAYTON-Wright Brothers Airport, south of Dayton, Ohio, were treated to a two-fer last September when replicas of the Wright B and Alberto Santos-Dumont's *Demoiselle* flew in loose formation. The latter, built by Brazil's Instituto Arruda, was en route to the National Air and Space Museum in Washington, D.C., where it starred in a celebration of the 100th anniversary of the maiden flight of Santos-Dumont's *14 Bis*, which on October 23, 1906, became the first heavier-than-air craft to fly in Europe. The flyable replica of the Wright B – the first mass-produced aircraft, flown by the U.S. Army Signal Corps for pilot training and reconnaissance – was constructed by Ohio airplane enthusiasts in the 1970s and is housed in the Wright B Flyer Museum at Dayton-Wright Brothers Airport, where it is available for rides.

The *Demoiselle* (top) teams up with a kindred spirit in Ohio last September.

Fly Us to the Moon

<<< ASTRONOMY enthusiast Anthony Ayiomamitis spent several years chasing down an image: He wanted a photograph of an airliner against the moon. Last July he finally caught it. "We need the plane to cover a specific area of the sky measuring 0.5 by 0.5 degrees, and to do so with the moon sufficiently high above the horizon and with a favorable phase," he writes. "Although the moon was only 25 degrees in altitude, relatively stable skies made for a successful capture." He points out that the nose of the airplane – which National Air and Space Museum curator Bob van der Linden identified at a glance as a late-model Boeing 737 – is just above the crater Tycho and just to the east of Lacus Excellentiae. That's where the European Space Agency SMART-1 spacecraft crashed last September, creating a plume of lunar regolith ejecta that was analyzed by astronomers searching for water ice.

BELOW: ERIC DUMIGAN; LEFT: ANTHONY AYIOMAMITIS; ABOVE: DAN PATTERSON

Born-Again Arrow

>>> FOR EIGHT YEARS, volunteers at the Toronto Aerospace Museum have labored over a full-scale model of a Canadian icon, the Avro CF-105 Arrow, a delta-wing supersonic interceptor of the 1950s immortalized in Canadian books, songs, plays, and films. Last October, the museum held a gala celebration, unveiling the permanent exhibit. Avro built five Arrows, but after production ceased by government order in 1959, all were destroyed.

NASA's Swiss Army Knife

FROM THE AGENCY intent on reinventing itself as a lean, mean, space-exploration machine comes an idea that may not only get NASA to the moon, but also one day remove the Hubble Space Telescope from orbit, rendezvous with an asteroid, and return soil samples from Mars.

It's a big calling for the small crew exploration vehicle NASA calls Orion. "These are good things to be thinking about so you do the engineering once," says Jeff Hanley, the manager of NASA's Constellation program at the Johnson Space Center in Houston.

Before the 2003 *Columbia* accident, NASA planned to keep the shuttles flying long enough to retrieve Hubble from orbit when its mission was over. Now, the agency could install a docking ring on the telescope that matches one being built for Orion, which sports a hefty propulsion module. "You could fly a CEV up to Hubble, point it in the right direction, and do a controlled reentry" to guide the telescope into the ocean, Hanley says, adding that this could be accomplished with a crew aboard or by using automated rendezvous and docking.

Of the potential missions to a near-Earth-orbiting asteroid and to Mars for sample returns, Hanley says, "We're building these huge rockets and big spacecraft, and we haven't even thought of all the ideas yet of how we could use it."

IRENE KLOTZ

Joe Sutter – "Father of the 747"

SEATTLE NATIVE JOE SUTTER is best known for leading Boeing's 4,500-member 747 design team in the late 1960s. After serving in the Navy on a destroyer escort in World War II, he went to work for Boeing in 1946, retiring after 40 years. Sutter, who was awarded the National Medal of Technology by President Ronald Reagan in 1985, is the author of *747: Creating the World's First Jumbo Jet and Other Adventures from a Life in Aviation* (Smithsonian Books/HarperCollins Publishers, 2006).

KATHY SAUBER/UNIVERSITY OF WASHINGTON

Joe Sutter poses with an airport artifact: rolling stairs for 747 passengers.

What influenced the way you designed aircraft?

The airplanes I observed [as a boy growing up near the Boeing plant] made me determined to give an airplane the ability to survive bad circumstances. That's why we have four flight control systems, four hydraulic systems, four landing gears [on the 747]. You know things are going to happen, and sometimes it's going to be severe. You still should be able to come home.

How did that help you design the Boeing 747?

At the start of a program, asking questions is the most important part of the process. If you get [the customer's] requirements wrong, then you don't have a successful product. In the case of the 747, we listened very hard to Pan Am Chairman Juan Trippe and the other airlines. One of the decisions we made was to be a good freighter as well as a good passenger plane – one of the most important decisions we made because it influenced [the size of the] fuselage. It's how the wide-body concept came into being.

Had you gone to work for Douglas Aircraft, which offered you a job after the war, would we instead be flying in a Douglas 747?

What's more important is the reason for the 747: Trippe and Bill Allen [Boeing's president from 1945 to 1968].... People that study the hell out of a problem, like they do now, would have determined the 747 wasn't worth the effort. It required Trippe's and Allen's vision. If they hadn't been in place, the 747 wouldn't have happened. Then you wonder, what would the industry look like today without it?

Douglas and Boeing were locked in a technological race that Boeing eventually won. What was the determining factor?

Boeing saw that people wanted more efficient, faster airplanes...[and] that the swept-wing and jet engine was the future of aviation. Douglas kept looking at the fact that military contracts are reliable – government money. Commercial airplanes are your own money. That made Douglas shy away from risky investment in commercial planes. Looking at it, no one in his right mind would want to get into this business. You don't start getting your money back for at least five years, so you bet the company each time you do a new project. Boeing has that culture, which comes from way back.

The *Enola Gay*'s Answer Man

Docent Scott Willey has worked closely with restoration director Bernie Poppert in the effort to return the B-29 to its 1945 condition.

FEW AVIATION ICONS inspire such intense degrees of awe, curiosity, and emotion as the *Enola Gay*, the B-29 that dropped the first nuclear weapon used in wartime, detonated over Hiroshima, Japan, in August 1945.

But any discussion of the airplane's significance can segue into the morality of strategic bombing during World War II, the Manhattan Project, the last political machinations of Imperial Japan, the start of the cold war, or the dawn of the atomic age.

An aircraft of such historical importance requires a particularly dedicated docent to field questions from the public at the Steven F. Udvar-Hazy Center in Chantilly, Virginia, where the B-29 is exhibited. On the walkway overlooking the *Enola Gay*, docent Scott Willey prepares to field questions from his position a scant few feet from the bomber's glass nose.

"Most of the time it's 'How many guys were on here?' " says Willey, a retired Air Force colonel who has donated his time to National Air and Space Museum facilities since the 1970s. "But sometimes it will develop into a deeper, almost philosophical discussion."

"I've been showing the airplane since 1979, and I've never had a Japanese tourist who has given me a problem. They don't come here and throw ashes or red paint. I've seen Americans do that, though."
–SCOTT WILLEY

The 60-year-old holds in the crook of one arm a 30-page binder containing pictures of the airplane's interior, black-and-white images of the dozen men who flew the *Enola Gay*'s most famous mission, maps of air fields, vistas of destroyed cities, and a photo of commander Paul Tibbets' mother, the airplane's namesake. It also contains data on almost all aspects of the war and postwar period. Willey compiled the information to aid volunteers, but he often recites even the most obscure information from memory. He also discusses the historical context of the mission.

"It's go/no go, black or white," he says of President Harry S Truman's decision to drop the fission-based atomic bomb, "Little Boy," over Hiroshima. "There are no gray areas in between."

Willey takes pains to represent both sides of the debate over the decision with respect, and to stick with facts. "You don't want to force your opinions on anyone," he says.

International visitors bring unique perspectives to the exhibit, but Willey says he has never encountered any anger from Japanese visitors, even those directly affected by the atomic bombings. "I've been showing the airplane since 1979, and I've never had a Japanese tourist who has given me a problem," he says. "They don't come here and throw ashes or red paint. I've seen Americans do that, though."

If there is anyone who can talk a visitor through elementary particle physics, the workings of a Norden bombsight, difficulties in calculating links between radiation exposure and cancer, what to expect when flying through shock waves, and the personal habits of the *Enola Gay*'s crew members, it is Willey. He has spent decades researching the history of the airplane, speaking with surviving crew members, and assisting restorers at the Paul E. Garber Preservation, Restoration and Storage Facility in Suitland, Maryland, getting the aircraft as close to its August 6, 1945 condition as possible.

Willey started as a docent in 1977, while on active duty with the U.S. Air Force. He lurked around the Garber facility, cleaning the warehouses, freeing the airplanes of birds' and rats'

nests, and occasionally helping to find misplaced items. Willey's wife, Linda, says he "went from colonel to janitor overnight." He retired from the Air Force in 1995.

Willey helped open two buildings at Garber to public tours (enabling the facility to show the pre-restoration *Enola Gay*), which have since shut down. He got certified to operate forklifts in a bid to become more involved in restoration projects, and uses a background in engineering to help with restorations (he is one of the very few docents who work on those projects). He still splits his time between Garber and the Hazy Center.

Willey's intimacy with the airplane helps him describe the tangled web of significance that spins from the *Enola Gay*. Manning the Museum's causeway, he seeks opportunities to strike up a conversation with visitors.

His favorite questioners are veterans. When the World War II memorial opened in Washington, D.C., in 2004, he spent four full days in front of the bomber, knowing many vets would swing by.

Willey says he does not debate the details of the possible invasion of Japan that the Hiroshima and Nagasaki bombings most likely prevented. "I generally will not bring up how this ended the war," he says. Those who served credit the *Enola Gay* and *Bockscar*, the B-29 that bombed Nagasaki, with saving their lives.

Willey can empathize. His father, Lee, was training as a gunner on Consolidated B-32 Dominators at Spokane Army Air Field in Washington, and was likely to deploy to the Philippines or Okinawa when the war ended. "He married my mom instead and they had me 11 months later," he says. "So you could say I owe my existence to this airplane."

You could add that Scott Willey is returning the *Enola Gay* the favor.

JOE PAPPALARDO

DANE PENLAND

Visitor Information

Curator's Choice Occasionally a National Air and Space Museum curator gives a 15-minute talk about an artifact or subject of interest at the Steven F. Udvar-Hazy Center in northern Virginia. Meet at the nose of the SR-71 Blackbird aircraft at 12:20 p.m. Dec. 7, The Airship *Akron*; Dec. 21, Spacesuits and Tools for the Moon.

What's Up Receive regular updates on Museum events, read about artifacts, get detailed (and behind-the-scenes) exhibition information, and receive calendar listings by subscribing to the National Air and Space Museum's free monthly e-newsletter, *What's Up*. Sign up at *www.nasm.si.edu*.

Donald D. Engen Tower The Udvar-Hazy Center has an observation tower from which visitors can watch air traffic arriving at and departing Washington Dulles International Airport. The only way to access the tower is via an elevator that rises 164 feet above the ground. The elevator can transport 15 people every five minutes.

New (and Discontinued) Bus Service The Virginia Regional Transportation Association is now offering convenient shuttle bus service between Washington Dulles International Airport and the Steven F. Udvar-Hazy Center. For detailed bus routes and schedules, visit *www.vatransit.org*, and click on "Bus Routes," then "Air and Space Museum shuttle." Shuttle service running between the National Mall building and the Udvar-Hazy Center has been discontinued.

ARTIFACTS

Watching the Oldest Light

THE UNIVERSE IS 13.7 BILLION YEARS old – give or take about 200 million years – according to the newest object in the National Air and Space Museum. The Wilkinson Microwave Anisotropy Probe, or WMAP, is a spacecraft currently recording the temperature of radiant heat left over from the Big Bang. Its most eerie discovery so far? Seventy-four percent of the universe is composed of a mysterious dark energy, which acts to accelerate expansion.

ERIC LONG

A reconstruction of the WMAP is in the Museum's Explore the Universe gallery – the flight model sits 930,000 miles above Earth.

Sea Legs for the Super Hornet

Nervous? Nah. An F/A-18F dirties up for its first carrier landing.

COURTESY FRANK MORLEY (2)

IN FEBRUARY 1996, the F/A-18 E/F Super Hornet Engineering, Manufacturing, and Development program got under way at the Naval Air Warfare Center at Patuxent River Naval Air Station in Maryland. The Super Hornet, 25 percent larger than the Hornet and with greater range and more powerful engines, had made its first flight the previous November at the McDonnell Douglas facilities in St. Louis. As a 30-year-old Navy lieutenant fresh out of test pilot school, I had followed this aircraft from individual components on the manufacturing floor through delivery to Pax River. And as one of the program's five test pilots, I began flying F1, the first F model, in carrier suitability tests as soon as it arrived.

Carrier suitability tests evaluated flying qualities, approach handling, failure modes, and loads testing, the latter using a ship's catapult and arresting gear installed on a Pax River runway. This testing really hammers an airplane. A carrier aircraft must be able to accelerate from zero to 175 mph in two seconds, and testing the maximum sink rate on landing requires descending at 1,600 feet per minute. By comparison, an airliner landing, even if not the smoothest, would not exceed a descent rate of 200 feet per minute, and an aircraft landing on a carrier normally descends at a mere 750 feet per minute.

In early November 1996, one of the test aircraft had a major engine component failure. It took a month to determine the source, and during that time the test program did not fly. The problem involved a minor modification of the compressor section, which would require at least another month to re-engineer. Fortunately, we had three of the original engines that had not been modified, and they were good to go.

Why not just delay? There was serious political discussion regarding the future of the three major fighter aircraft programs in progress—the Super Hornet, the F-22, and the Joint Strike Fighter. The Super Hornet was first to begin testing and was a priority for the Navy, with Initial Sea Trials a big milestone. Any slip would make the program vulnerable.

On December 15, I took F1 up for a check flight of its newly installed engines. Because we were now more than a month behind in our preparations for sea trials, we went right into arrested-landing loads testing. All went fine with the checkout flight, and 30 minutes later I was at the proper landing weight and on final for what was to be the first of many arrested landings that day. I caught the wire and came to an abrupt stop, going to full power just as I would on the carrier to ensure I would go flying again if I missed all the wires and "boltered"—took off for another try. Then I heard Howard Gofus, my test conductor, say, "Idle power! Idle power! Oh no!"

Gofus, a very cool fellow whom I trusted implicitly, was not one to get overly excited on the radio. I immediately went to idle power and radioed, "What's wrong?" Gofus had seen sparks come out of the right engine. We shut the airplane down and towed it back to the hangar. As we suspected, upon landing, the right engine had ingested a piece of metal, or FOD—foreign object debris—that had torn it up. Now we were down to two engines and one month to sea trials, during which we needed to fly six or seven days a week. We needed

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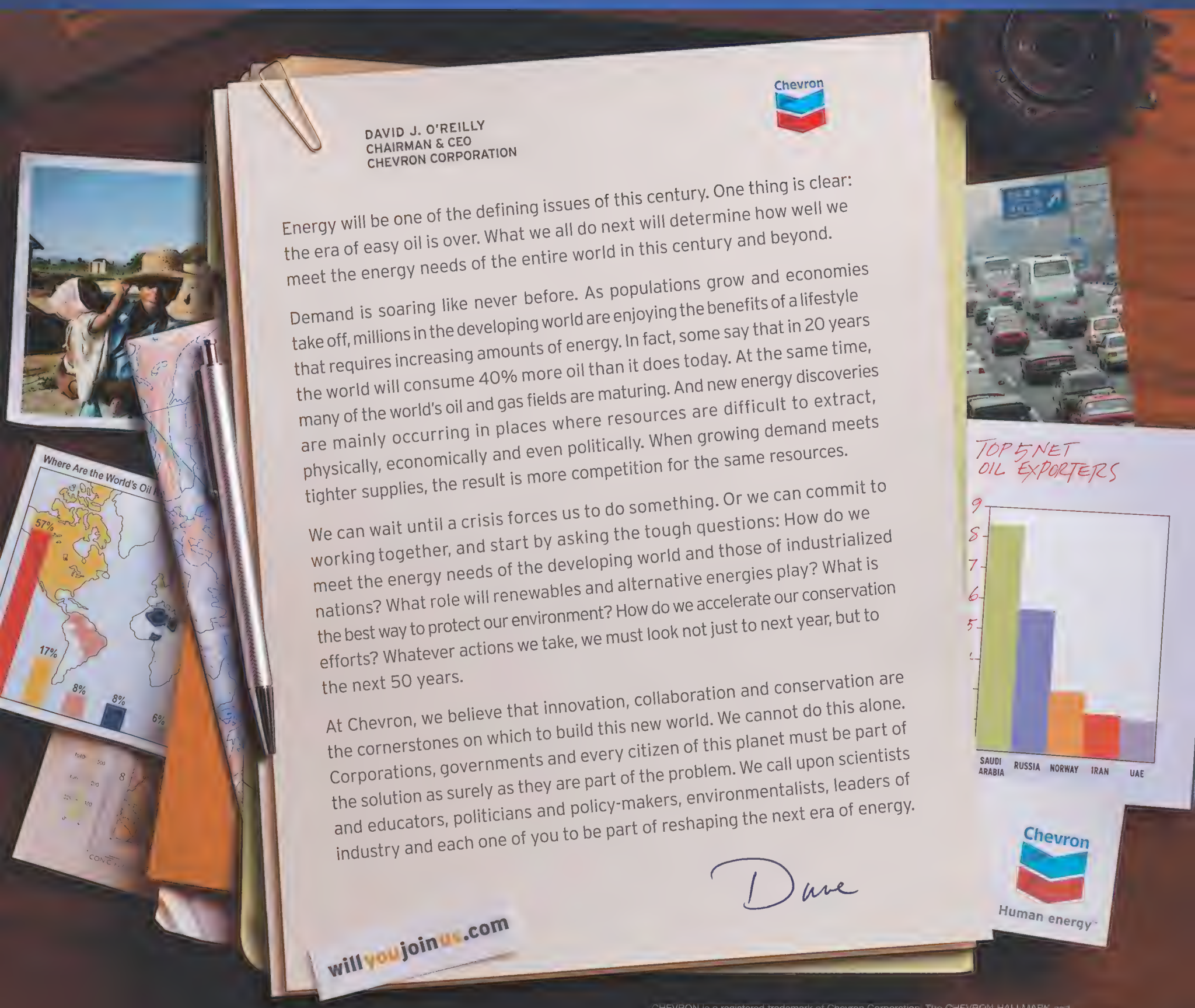

bold measures to ramp up our chances of success.

So, rather than risk FOD-ing our remaining engines, we towed F1 from the hangar to the runway. Before starting the engines, we brought most of the local Super Hornet test team—about 400 people—to walk down about 3,000 feet of runway looking for any possible FOD, like a stray bolt. Once the FOD walk was complete, we started the jet, made all our checks, and took off. On the final landing, we would come to a complete stop, do all post-flight and shutdown checks on the runway, and tow the aircraft back to the hangar.

Then we found that during field arrests, our hook point, the piece of the tail hook that engages an arresting wire, was cracking. In normal test practice, we start with baby steps: one trap only for the new hook point; change hook points and analyze any fatigue issues with the old one. We redesigned the hook point, and by sea trials, we had the new design cleared for five arrested landings before it would be changed. We felt pretty good about it, but it was yet another nagging issue that sticks in your head.

On the cold, crisp, clear morning of January 18, 1997, Elizabeth, my wife of four months, dropped me off at the hangar at 3:30 a.m. The aircraft carrier USS *John C. Stennis* was off the coast of North Carolina. Weather was great along the eastern seaboard, although satellite images showed the possibility of moisture at sea. On the ship, our team reported they were in some weather, but they expected to be out of it by our scheduled arrival time, 8 a.m.

Tom "Gurns" Gurney manned the chase aircraft with a Pax River photographer. Startup was normal. It was extremely motivating to see our test team giving me thumbs up and smiles as I ran the engines up and began the takeoff roll. Things were looking good.

Off the North Carolina coast, Gurns and I saw that the ocean was "steaming," due to the unusually cold air mass sitting over the warm Gulf Stream waters. Farther out to sea, the clouds below us thickened. Our program director came up on the radio and said, "We've got a little weather down here—zero visibility and blowing snow." *Great,* I thought. We arrived overhead at 25,000 feet and flew a holding pattern while the ship looked for better weather.

The author gets a little face time with the Super Hornet after nailing the first carrier landing. Don't call the F/A-18E/F an "upgraded" Hornet: The Navy will object. The E/F is a whole new airframe, and larger too.

The air boss, charged with running air operations, said, "Gurns, come on down, find the ship, and maybe point us in the right direction—we're still in a snowstorm." Gurns headed down while I circled. He found the ship in about 10 minutes and told them to head west, where there was good enough weather to give me a go-ahead.

I was expecting the standard carrier instrument approach when instructions came via the air boss: "Find the ship, enter the break, and get to work." Never heard that approach before, but I liked the sound of it.

I got the usual data from the Landing Signal Officer—"Working 42 knots, four-degree glide slope"—meaning there was 42 knots of wind across the flight deck and a four-degree glide path required for landing. Not good. Optimum is 25 knots and a 3.5-degree glide slope. The relatively high "natural" wind—wind speed minus the forward speed of the carrier—necessitates a steeper glide slope to increase clearance over the ramp (the back of the ship), because the strong downward force of the natural wind tends to pull the aircraft down just before the aircraft reaches the ramp—also not good. It's not like we'd never flown in these conditions, but they were far from ideal for a first trap.

I found the ship, Gurns found me, and we came into the break in formation. I had fuel for one low approach and then two attempts at landing before I would have to divert to a shore base. Gurns followed me in the chase plane and the photographer got some great pictures and film footage.

My biggest concern, outside of the jet not working as advertised or me making a mistake that would let the program down, was boltering. Carrier pilots take pride in getting aboard on the first attempt. Besides the flight deck crew, the only people on deck were the rows of media photographers filming the landing. If I boltered, I would be seeing replays for years.

The airplane performed superbly, even in the less-than-ideal conditions, and the hook point did not crack (it's now above my fireplace). I caught the third of four wires and got the grade of "OK 3"—meaning rock-solid on speed, on the glide slope, and catching the intended wire.

The weather got worse and we decided to shut down until it cleared. One week, 63 traps, 63 catapults, and many more low approaches and touch-and-gos later, the Super Hornet passed its Initial Sea Trials.

When I got down to the ship's ready room after the first trap, I found that the 100-plus team members on hand supporting the effort had established a betting pool on which wire I would catch. All names and votes were on a board. The majority had bet I'd come down on the 2 wire, or, worse yet, knowing I did not want to bolter, the 1 wire. The truth is, I barely cleared the 1 wire, the hook skipped over the 2 wire, and I caught the 3 wire. Sheer luck.

FRANK MORLEY

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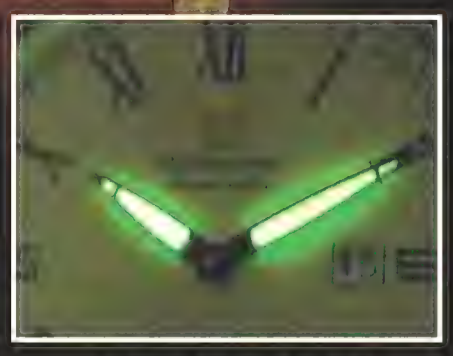

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The Pi-Balls of My Youth

AS THE DAUGHTER of an aerospace engineer, my childhood was blessed with big balloons—leftover or rejected weather balloons that my father brought home as playthings for my brothers and me after a day of testing.

Dad worked for what was then the Air Force Cambridge Research Laboratories at Hanscom Field in Bedford, Massachusetts. The U.S. government had been using high-altitude balloon technology—primarily to obtain weather data—since the late 1940s. The earliest of these so-called pi-balls (short for pilot balloons) to reach our eager little hands were tough-skinned black or yellow spheres about the size of a beach ball.

In the 1950s, the Balloon Research Group of AFCRL's Research Instrumentation Laboratory began launching manned balloon-borne gondolas to high altitudes to test the effects of the space environment on humans. Thus, as we grew, so did the balloons Dad brought home.

By the time I was in middle school, we had graduated to huge, flimsy helium balloons, which we'd re-inflate in the back yard with the vacuum cleaner hose. Caught by the wind, these massive orbs would sometimes escape and sweep through the neighborhood as Dad, my brothers, and I gave chase along with a growing legion of envious youngsters.

We discovered, quite by accident, that sucking on the opening of a deflated helium balloon would make our voices sound like cartoon chipmunks. One afternoon, we pulled a spectacular prank on my mother by filling the living room with a partially inflated balloon that billowed wall to wall like an undulating blob.

The Balloon Research Group was a vital part of the U.S. space program by 1962, and four years later, NASA proposed an ambitious application for its balloon technology: testing a parachute for a planetary probe. A rocket, to be launched from a high-altitude balloon, would carry the prototype for a probe to land by parachute on other planets.

The Planetary Entry Parachute balloon system stood taller than the 555-foot Washington Monument.

How big a balloon would it take to lift NASA's hefty payload to 130,000 feet? A whopper—the largest balloon on record at the time, constructed of acres of thin polyethylene, Mylar, and nylon film.

On the runway of the former Walker Air Force Base in Roswell, New Mexico, on the morning of July 28, 1967, the main balloon measured 570 feet in length before inflation, with a capacity of 26 million cubic feet. Dad remembers a co-worker's comment upon surveying the trail of uninflated balloon: "That's a big mother bear, Mr. Prevett!" Attached to the empty main balloon was a parachute train for landing the AFCRL's control equipment and, below that, a load bar with packages of balloon instrumentation and ballast. Finally, grasped by a huge 30-ton crane was NASA's rocket with its cone-shaped aeroshell. Tucked inside the capsule was NASA's parachute, which would brake the freefall of the simulated planetary probe as it plummeted to Earth.

It all worked like a charm: The balloon reached the target altitude, the rocket was launched, and the capsule was ejected at 140,000 feet and began a 1,100-mph freefall. The parachute unfurled right on cue and the equipment package floated safely to planet Earth.

I was by then nearly 20, and my mind was occupied by things seemingly loftier than balloons. So it was not until the tests came to fruition with the Viking and Pioneer landers on Mars and Venus in the following decade that I began to appreciate the significance of Dad's balloon launches. In December 1995, with the parachute descent of the Galileo probe into Jupiter's atmosphere, my father experienced the crowning achievement of his career. And by then, I was mature enough to appreciate it.

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the PHYSICS

To me, the most enjoyable kind of racing involves laps around a circuit. Whether it's at the Reno air races in Nevada or NASCAR's Richmond International Raceway in Virginia, all the competitors are within view throughout the entire event. Races on road courses that take the field out of sight for minutes at a time aren't as much fun; same goes for cross-country air races. Drag races are over before they begin. Whether the racers are in cars or airplanes, being able to see the lead changes and race tactics makes the experience more exciting. Ask NASCAR, which has discovered the master key to motor racing popularity in oval-track racing, some on courses as short as Tennessee's Bristol half-mile circuit, where a straightaway may take only a couple of seconds. NASCAR fans live for the action in the turns.

On the straights, the dominant factor is a racer's horsepower, but the moments that bring racing fans to their feet tend to occur when close competitors are battling through turns. It's as true for air racing as it is for stock cars: Some racers, perhaps gifted or simply well trained, make each lap seem effortless. And these are the competitors who seem to win most often. Is there something at work here—some law of physics, perhaps—that rewards smoothness in executing a turn? And despite the marked differences in the machines, are there elements common to successful turning in both road racing and air racing?

I asked experts in both fields to examine the factors that make for a fast lap on the ground and in the air. It was unanimous: The most important element to racing is the line—the path that defines the fastest way around any turn, the curving path that connects the entrance to a turn and the exit from it. In oval-track racing as well as at Reno, there are at least two turns on the circuit, each producing a reversal of direction. This is where races are won and lost.

by George C. Larson

WAYNE SAGAR/AAFO.COM

For car racers and air racers alike, a checkered flag says: Winnah!

Yet two perfectly matched race cars can, in the hands of different drivers, deliver different results. What makes a winner? Stephan Wilkinson is the author of *The Gold-Plated Porsche*, a memoir about restoring a 911SC that he drives at race tracks for the sheer pleasure of going fast legally. (He's also a pilot and contributor to *Air & Space/Smithsonian*.) "Smoothness counts for a lot in a car," he says. "And I wonder

ARNOLD GREENWELL

AP PHOTO/ERIK FEBEL

Racers heading for the starting flag at Lowe's Motor Speedway in Charlotte, North Carolina (above), play by the same physical rules as Grumman F8F *Rare Bear* and P-51 *Ridge Runner III* vying for the lead at Reno.

of WINNING

WHAT RENO AIR RACE WINNERS KNOW THAT LOSERS DON'T.

RICHARD VANDER MUELEN

Mary Dilda's seemingly languid technique has won three Gold races. The key, she says: Minimizing control inputs, which minimizes drag.

if there's a parallel there with air racing. I always instruct people to imagine that their car is like a big beach ball, and that it tips or pitches in response to braking, accelerating, turning. You can't do these things 'gently' at racing speed, but you can do them smoothly. You can always tell the inexperienced drivers, whether it's in movies or on the track: They jump on the brakes, jump on the gas, saw the wheel...all that too-fast-too-furious stuff is the antithesis of what a competitive driver does."

Race car teams spend a lot of time adjusting tire pressures and suspension springs to find the sweet spot where the driver feels comfortable in turns. The mechanics try to balance understeer, or "pushing" in NASCAR lingo, and oversteer, a condition NASCAR folks call "loose." With understeer, a car wants to head toward the wall rather than follow the front wheels around a turn; with a lot of oversteer, the rear end of the car wants to head to the wall—come loose—and thereby point the nose of the car deeper into the turn. In essence, the car turns more than the front wheels want it to: It oversteers. In either condition, turns will cause the car to lose speed.

Though air racers don't have the colorful lingo of the good ol' boys on the Nextel Trophy circuit, they do much the same thing with their airplanes. Most try to relax the airplane's static pitch stability by moving the center of gravity as far aft as possible without making the airplane unsafe in slow flight. This reduces the work the horizontal tail has to do to keep the airplane balanced in turns (see "Balancing the See-Saw," below), and reducing the workload of the tail reduces drag.

Mary Dilda took the North American T-6 Gold race at Reno in 1997 and 2005 and the Jet Class Gold in 2003. To dissect the technique that makes her flying appear so languid, she narrates a hypothetical three-pylon turn: "First, create the least amount of drag," she says. "The ailerons create drag when you enter a turn, so ideally you plan the turn...and begin the roll early, very slowly, barely putting aileron in, a little rudder to keep the nose down as you roll in. You start early enough and hold your bank all the way around the pylons and slowly roll out after the third pylon. So you never think about the second pylon and just create as little drag as possible with the ailerons."

Assistant and husband Steve adds, "We watched a lot of race car drivers. When they enter a turn, they try to [steer along a path] so they generate the least amount of wheel movement, and that's less drag they're creating on the car. That's exactly what we try to do, so their steering wheel and our control stick are identical.

"Anytime we pull back on the stick, the elevator deflection increases drag. Anytime you can make a turn with the least amount of control deflection—the least amount of drag—that's your goal.

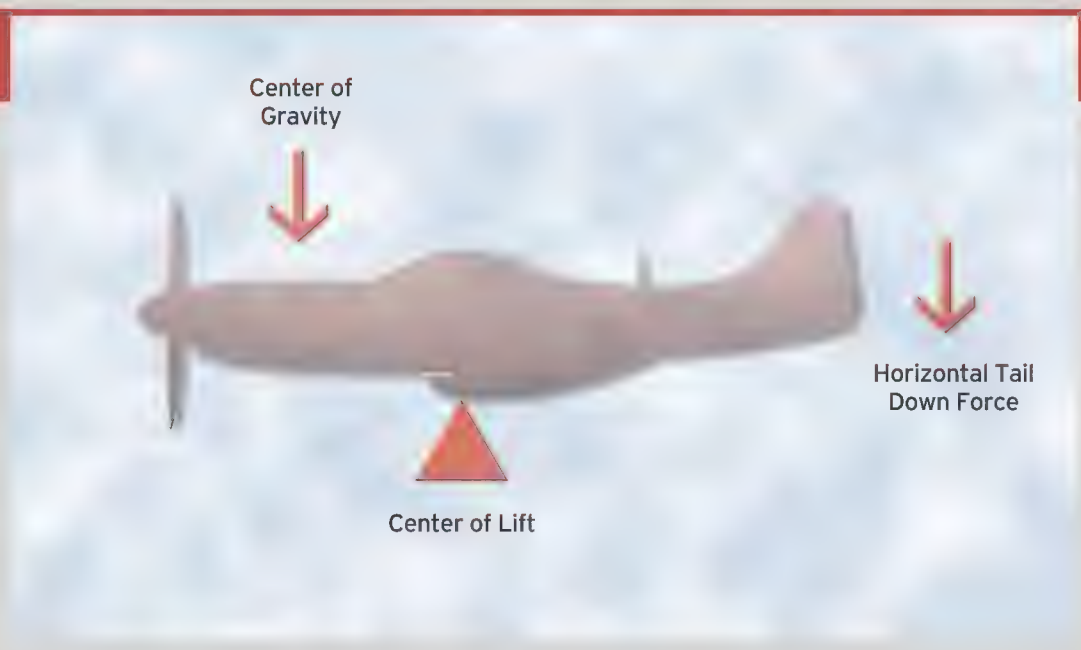
"It's a matter of both talent and mastery. Some people are very mechanical and have to think about [flying smoothly and minimizing drag]. Others don't concentrate as hard but still have to think about it." Steve Dilda thinks you can see the differences in technique during a race: "I've seen it on videos: airplanes that look like they're flying on a rail. Others you see skidding around turns, nose up and not going anywhere."

Todd Serota is a California lawyer, novice pilot, and Massachusetts Institute of Tech-

OPPOSITE TOP: DAVID PETERS

Balancing the See-Saw

CONVENTIONAL AIRPLANES ARE built with the center of gravity (CG) forward of the center of lift, a point on the wing where the sum of the wing's entire lift force is centered. It's a theoretical point, but calculation of its location is part of designing any wing. Think of it as the fulcrum on which the airplane is balanced in flight. Because the CG is forward of that balance point, the airplane would pitch nose down were it not for a counter-force from the horizontal tail, which is like an upside-down wing: Its lift vector points down. At high speed, with lots of airflow over the tail surface, the tail exerts a generous downforce to balance the airplane in the pitch axis. At slower speeds, airflow produces less downforce and pilots have to compensate by pulling back on the stick to deflect the elevator upward or by adjusting pitch trim to accomplish the same thing. Moving the CG to the rear reduces the degree the tail must be deflected, and this produces less drag and higher speed.



nology grad who put together events that placed fellow MIT grads in race cars for a day. Eventually it grew into a business, Tracquest, which he recently sold. He estimates that he has instructed drivers at some 200 events. "In my driver meetings, I stagger the sessions for advanced, intermediate, and beginning drivers," he says. "When I address the novices, I remind them of the old saying about real estate [location, location, location]. I semi-jokingly tell them that driving is the same: It's smoothness, smoothness, smoothness." But he says that the repetition of "location" actually emphasizes that in real estate, there's only one factor, whereas the equivalent phrase in racing refers to three distinct factors. "They are [steering] wheel, brake, and throttle," he says. "So [in racing], smoothness has a triple meaning."

When aircraft are identical, as in this T-6 race, it's piloting technique, not horsepower, that determines the winner.

The popular perception may be that he who hugs the ground and the pylons wins, but that's not how leading racers describe the best line. "It's the fastest way, not the shortest," says Lyle Shelton, veteran racer and owner of the Grumman Bearcat *Rare Bear*. "I had an engineer plot it out. He plotted a constant-G line, the fastest way around the course. I'd figured

ARNOLD GREENWELL

RICHARD VANDER MUELEN

In the maintenance-intensive Unlimited class, engines and airframes are routinely pushed beyond their limits in the quest for gold (above). A P-51 Mustang prudently observes the air racer's 11th commandment: Thou shalt not cut a pylon (right).

RICHARD VANDER MUELEN

ARNOLD GREENWELL

A pair of Hawker Sea Furies skim the ground in a turn, where air races – and auto races – are won or lost (left). The heavily modified P-51 *Dago Red* has won Unlimited Gold six times, most often with the legendary Skip Holm in the cockpit.

it out myself by the seat of my pants by that time." Shelton says he doesn't like to exceed 4 Gs around any turn. "You get it built into your britches. I like about 3.5 G, never more than 4."

He uses different words—the "softer" turn is faster—another way of stating what the Dildas observed. "It didn't take me long after I started racing in 1965 in a P-51 to learn that softer turns made faster speed." He no longer flies the *Bear* himself, but Reno race fans still talk about Shelton's fluid line. "Instead of running up on a pylon and honking it around the pylon, the most constant bank you can use works better," he says.

If a car is at a speed that puts it at the limits of tire adhesion as it enters the turn, centrifugal force will carry the car off the track—it spins out. The simple act of steering forces the tires to work harder in a lateral direction, adding friction and scrubbing off speed. One difference between cars and airplanes is that pilots race with the throttle at its forward stop, whereas car racers back off the gas when entering a turn, then floor it when they accelerate out of the turn.

When a pilot pulls a 70- to 80-degree bank in turns, the Gs scrub off speed the way the friction of the front tires does on cars. To pull those Gs, pilots are pulling the stick back, pitching the nose up toward the inside of the turn and increasing the angle of attack of the wings to increase their lift and counter the centrifugal force that can make a 200-pound pilot

The Racers' Edge

YOU DIDN'T REALLY THINK IT WAS ALL FLYING SKILL AND NO AIRSPEED TRICKS, DID YOU? HERE ARE SOME MEASURES AIR RACERS TAKE TO STAY IN FRONT OF THE PACK:

Lyle Shelton, *Rare Bear*

"We like to have a little aft CG [center of gravity]. If we carry a bunch of gas and a bunch of [nitrous oxide, a gas injected into engines to enrich the oxygen content of the fuel-air mixture], we start with too much aft CG. You might be halfway through the race before you get optimum, which is [with the CG] slightly aft, which reduces the [required] downward component [force] of the horizontal stabilizer."

WAYNE SAGAR/AAFO.COM

Shelton on the ideal G level: "You get it built into your britches."

Mary and Steve Dilda, *Two of Hearts*

"Car racers look for the perfect tire and suspension. In air racing, we're looking for a propeller tuned to the airframe and balanced to the engine. It's a prop-engine-airframe mix, and it's taken us seven years to find it. We look for a very smooth airframe. You pressurize the inside of the airplane to prevent outside air from entering, except that it's extremely uncomfortable at about 130 degrees [Fahrenheit] and no airflow. We put a fan behind the instruments. We tape everything, every seam, to smooth airflow and prevent disruptions. Even the wheel wells are sealed."

ARNOLD GREENWELL

Destefani (at left) toasts 2006 Unlimited Gold winner Michael Brown, while fans photograph their idols.

Bill "Tiger" Destefani, *Strega*

"The Mustang was a compromise. The engine is set in there with a thrust line of 1 or 1.5 degree upwards [the engine tilts up slightly]. We had to change that. The Mustang also had 1.5-degree kick [angle away from centerline] right on the vertical tail. We make it zero. The stock Mustang at 400 mph will take six degrees of left rudder trim to fly straight, and they tweaked the rudder to help those 18-year-old pilots [during World War II]. You take it out so there's no rudder trim, no wing trying to raise, no aileron trying to rise. We clipped the wings 30 inches, so you have to land it faster. You have less drag, but it's speedier on landing and takeoff."

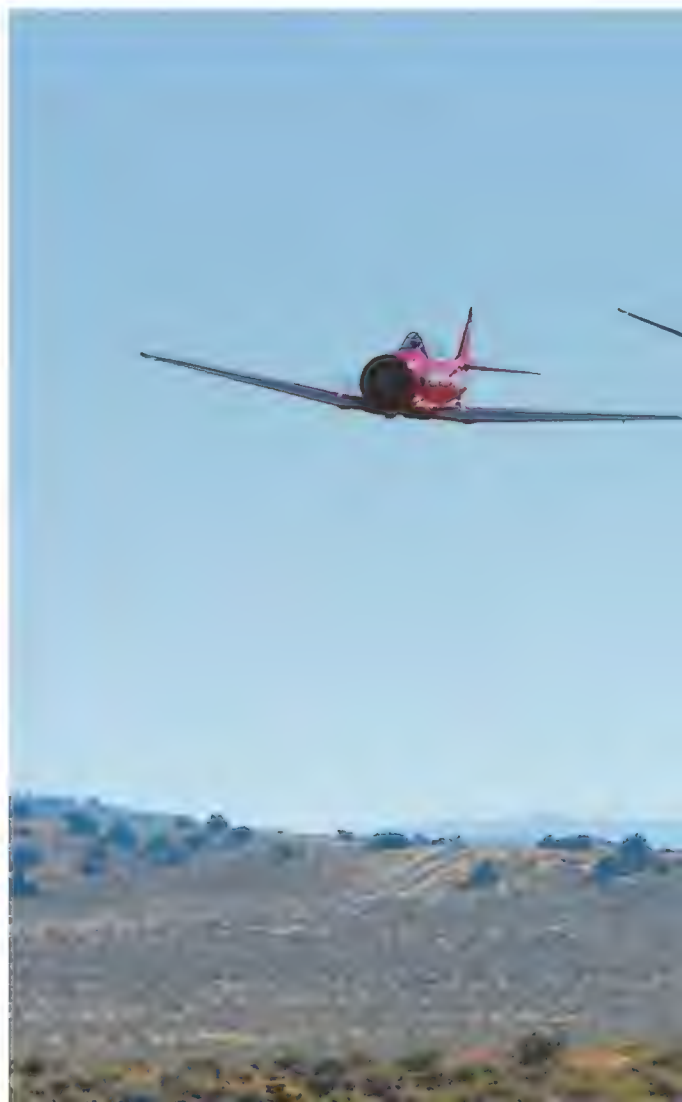
feel as though he weighs 800 pounds.

In the 1990s, Bill "Tiger" Destefani flew the modified P-51 *Strega* to victory against competitors with more horsepower. He explains his advantage in terms of pulling Gs: "You've got to get through the turn with the least amount of Gs. Gs equal drag. We'll put enough weight in the tail so if you're pulling up to 4 Gs in a turn, the tail-heavy airplane goes faster." Flying *Strega* was all finesse, he says. "No rudder in the straights. In the turns, just a l*iiii*-tle bit." His team went to great efforts to remove every last bit of trim pressure that would be exerted at top speed. Even a small surface like a trim tab or a tiny control deflection adds drag.

Steve Potter, vice president and general manager at Lime Rock Park, a race track in Connecticut, says his first experience in a race car was very different from how he'd imagined it, and he's spent years thinking about the challenge of driving at speed—and about the line.

"In the entire span of nature's time, until an eye-blink ago, humans lived in a 20-

Gaining on the guy in front puts you in the turbulence of his prop wash, where, as these T-6s demonstrate, it's a struggle to hold your line.



WAYNE SAGAR/AAFO.COM

RICHARD VANDER MUELEN

Air racers enter the "track" in close formation, but crossing the finish line, there's always a Number One...and Number Two.

mile-per-hour world. All of our sensory systems have evolved to live with that. The trick is to slow the world, when you're in a vehicle, down to 20 mph. Look out a side window, and at 50 mph, the guardrail is a blur. If you look far enough down the road, things are not approaching very quickly. To follow the line around a race track, it's critical to learn to look far ahead and ignore what's close."

All well and good when you have a track to yourself at the Indianapolis 500 time trials or you're just running practice laps at Reno. In real-world racing, you can find yourself in traffic or in somebody's prop wash. And you can't expect to enter every turn at precisely the right point. Racers learn to compensate when they can't follow the ideal line or when they make a mistake and have to correct for it. On the track, drivers are trained to make optimum use of the tires' grip by using part of their adhesion for braking, part for cornering, and part for acceleration out of the turn—all influenced mightily by the line through the corner.

A driver has the right to defend against being passed, and swinging wide in a turn is one way to block. That happened to Mary Dilda when she was trying to pass a competitor in 2005's T-6 Gold race: "When he would roll into a turn, he was delaying the roll and hoping I was [flying as if in formation]. I flew my own line a little higher." Although that gain in altitude might have forced her to expend energy, she says, "I didn't have the G forces that he had to pull. He had to pull harder through the turn." She got her spent energy back coming downhill after she passed the competitor's T-6 handily.

"Sometimes in traffic, you get away from the optimum [line]," says Shelton. "You go outside somebody because of traffic or prop wash. Prop wash can whip you past vertical [90-degree bank] and really gets your attention. The wing can get stuck in the vortex and it won't come out. Then it whips out, and it's really a violent thing. Then you've got to settle back in."

Though altitude gain and prop wash are alien to race car drivers, air racers and auto racers still have a lot in common. Shelton sums it up: "I've gone to the Motorsports Hall of Fame and talked to the auto, motorcycle, boat guys, and others, and we all talk the same language."

Resto

Lake Murray's Mitchell | B-25C

At about 10:45 a.m. on April 4, 1943, Bryce Lever was looking for fishing worms on the south shore of Lake Murray in South Carolina when he saw an airplane flying low, heading toward the water.

Katherine Townsend Tapp, 23, was strolling on the lake's north shore when she saw the ailing aircraft, a B-25. She hurried to the home of Sewall Oliver, who had a speedboat that could be used in a rescue. Nearby, Martin Jones Jr., 10, also saw the aircraft descend; he yelled to his brother that one of the engines was out.

Martin had a sharp eye. After the B-25 had taken off from the Army Air Base outside Columbia, South Carolina, on a skip-bombing training mission over the lake's island targets, its left engine had lost power. The base was a good six miles away, so Henry Mascall, the bombardier, urged pilot William Fallon to land on the lake. The airplane ditched about two miles west of Dreher Shoals Dam.

The crew climbed out onto the wings, then inflated a life raft and set it in the water. Sewall Oliver eventually rescued them all in his speedboat.

About seven minutes after impact, the aircraft began sinking. It finally ended up at the bottom of Lake Murray, at a depth of 150 feet—too deep for the U.S. Army Air Forces to salvage it. It was written off as a loss.

Growing up in Columbia decades later, Robert Seigler heard tales of the sunken bomber and was intrigued. In the 1980s, Seigler began researching the crash. Along with two partners, John Hodge and Bill Vartorella, Seigler formed the Lake Murray B-25 Rescue Project to get the aircraft out of the water. "This really is a hobby gone awry," Seigler says today of his decades-long campaign.

The aircraft's rarity made it worth the trouble. The B-25 Mitchell, a medium bomber used in both the European and Pacific theaters of World War II, was once plentiful: North American Aviation made nearly 10,000. Today, some 130 remain, and the one from Lake Murray is the third oldest. It is one of only four intact C models surviving, and the only B-25 that still has a bottom gun turret.

Seigler's group had sonographers search for the aircraft in the early 1990s, but they had no luck. Then in 1992, a Navy unit took on the search as a training exercise. The following year, using side-scan sonar and the accounts of witnesses, including Katherine Tapp and Bryce Lever, the divers located the airplane in the 78-square-mile lake.

NASM (SI NEG. #9A00141)

The C was the first B-25 with a navigator's blister (behind the cockpit).

Robert Seigler (below, at the salvage site) worked for two decades to rescue the B-25. Right: When the left engine failed, the copilot brought up the power in the right one, as the forward-most throttle still showed 62 years later.

JEFF AMBERG (2)

ration

Subsequently, Seigler's team spent more than a decade trying to raise money to attempt a salvage. Finally, in 2005, they hired Gary Larkins, with 68 salvages perhaps the world's most successful aircraft retriever (see "Gary and the Pirates," Feb./Mar. 1997). Starting September 10, Larkins began directing a salvage attempt. A barge was positioned above the airplane, and eight divers in two-man teams dove into the lake several times daily to inspect, clear silt, and secure the airplane. They worked as long as 18 hours at a stretch. At times, visibility was limited to inches. Larkins instructed the divers where and how to attach straps around the wings and spreader bars over the wings to distribute the weight for safe lifting. When all those were in place, the barge slowly raised the airplane and towed it to shore, just below the surface.

Just before midnight on September 19, hundreds of onlookers in boats and on land watched, spellbound, as a crane finally hoisted the airplane to the surface. A total of 800 gallons of fuel and water was pumped from the bomber before it was lifted clear of the lake. The aircraft was then dismantled, and the parts were cleaned, inventoried, and photographed.

Seigler's group had arranged to give the B-25 to the Southern Museum of Flight in Birmingham, Alabama, and in December 2005 the front section went on display there.

Jim Griffin, the museum's director, says that the B-25 is being preserved, not restored to pre-crash condition. The decision was based in part on the aircraft's damage, which the museum judged too extensive to repair. When the bomber hit the lake, for example, the right engine had been torn off.

The cockpit is a different story. Artifacts from there turned out to be well preserved, and will be displayed with the B-25. Navigation charts and a 1943 section of Columbia's *The State* newspaper are still readable. Also retrieved: four .50-caliber machine guns and one .30-caliber gun, buttons, parts of parachutes, bombsights, a tooth-marked olive drab pencil, headsets, earphones, a pair of leather driving gloves, a portable potty, radios, and the watch of copilot Robert Davison, inscribed "RUTH TO BOB 3-5-43." "We found out last week that Ruth is still alive and was angry with Bob because he lost [the watch] after she had given it to him a month before," says Griffin. "She still had a year to pay on it."

Work on the rest of the B-25 is very slow. Volunteers are using dental tools to remove corrosion. "As we preserve various parts, they will be added to the display," says Griffin. Eventually, the entire aircraft will be shown in an underwater-like setting, resting in a bed of sand.

KAY GORDON

JIM GRIFFIN/COURTESY OF SOUTHERN MUSEUM OF FLIGHT (2)

JEFF AMBERG

Left: Assistant Director Wayne Novy (at left) and volunteer Geoff Mason of Alabama's Southern Museum of Flight attack corrosion. Below: After the salvage, museum workers disassembled the B-25 and inventoried the parts on site. Among the artifacts recovered: an engraved watch (below left) that turned out to have a decidedly unromantic story behind it.

MYSTERY GUADALCA

IN THE WRECKAGE OF A WILDCAT LAY CLUES TO WHAT HAPPENED IN A FAMOUS

DURING THE OPENING HOURS of the U.S. assault on Guadalcanal, the air battle produced one of the most storied combat engagements of the war. After a ferocious exchange of fire, Japanese ace Saburo Sakai shot down a Wildcat, flown by Lieutenant James J. Southerland II. Southerland bailed out and survived. The wreck of his airplane lay hidden for 56 years. In 1998, it was discovered, right where it had fallen.

by Ralph Wetterhahn

The more inhospitable its resting place, the better the chance a wrecked airplane has of remaining untouched by scavengers and curiosity-seekers and the more likely it will still hold secrets for historians. Thousands of such ruins remain throughout what was known as the Pacific theater—on rugged mountaintops in New Guinea, in jungle ravines in the Philippines and the Solomons, scattered across tiny islands and a vast area of ocean floor.

Justin Taylan has been cataloging the location of those aircraft wrecks since 1993, when he toured the Pacific battlefields with his grandfather, a combat photographer in the South Pacific during World War II. A serious 28-year-old, Taylan founded PacificGhosts.com to locate and document the wrecks, about 30 of them in the Solomon Islands. He has visted more than 200.

His company maintains a database detailing the research and has produced a CD-ROM on more than 30 of the wrecks (see Reviews & Previews, Apr./May 2003). When I met Taylan, he was publicizing his work at the Planes of Fame Museum at Chino Airport, California; it was the day of an airshow, and a good-size crowd had gathered to look at his photographs and hear him describe his expeditions. We talked about one of his most significant discoveries, the wreck of Southerland's Grumman F4F Wildcat. It is believed to be the first U.S. Navy aircraft to shoot down an enemy in the Battle of Guadalcanal. It was also one of the first U.S. aircraft shot down in that battle. Both Southerland and Sakai were seriously injured—one stranded behind enemy lines, the other 560 miles from his base—but both lived and later told what happened that day.

Historians know Southerland's version of the events of August 7, 1942, mainly from his after-action report, which was published in the *U.S. Naval Institute Proceedings* in 1943. His aircraft carrier, the USS *Saratoga*, was one of three tasked with providing air support for the assault on the Solomons and protecting the Navy ships massed off Guadalcanal and Tulagi. The months-long campaign was the first Allied offensive in the Pacific, and it marked the end of Japanese expansion.

The pilot who shot Southerland down, Petty Officer First Class Saburo Sakai, would become one of Japan's greatest aces. His version of the dogfight appears in the 1985 book *Winged Samurai: Saburo Sakai and the Zero Fighter Pilots* (Champlin Fighter Museum Press), written by Henry Sakaida and based on Sakai's memoirs and on interviews with him. Sakai's war career became well known with the 1957 autobiography *Samurai!* (E.P. Dutton and Company), written with aviation historian Martin Caidin. Both Sakaida and Caidin report Sakai's claim that he could have killed Southerland, but showed mercy by firing at the aircraft's engine instead of its pilot. In other significant details, the two pilots' versions match, but both could only surmise why Southerland was unable to fire on Sakai when his Zero slid in front of the F4F (see "The Dogfight," p. 34). After meeting Taylan, I hoped to examine the wreckage of the Wildcat to find out.

Taylan first saw the crash site in 2003. An islander, Edilon Gii, had come upon it in 1998, and led a group of historians there—among them, Michael Claringbould, who worked with Taylan on the PacificGhosts CD. Last winter, Taylan returned with a documentary film crew from Cineflix Productions in Montreal. Because I had assisted film director Michael Barnes with crash investigations in earlier projects, I was retained to analyze the wreckage of the F4F for the documentary *Dogfight Over Guadalcanal*, which aired in early November on WGBH's

ON NAL

WORLD WAR II DOGFIGHT.

A rusting ship sunk during the Battle of Guadalcanal was for years a symbol of the Japanese defeat. Wrecks are still being discovered in the island's interior.

ABOVE: NAVAL HISTORICAL CENTER 80-G-K-1467-A

"NOVA: Secrets of the Dead" series.

On a hot January morning, with cameras and sound gear, we followed Edilon Gii into the jungle. A farmer and hunter (Gii had discovered the wreck in a ravine while hunting wild pig), the 42-year-old guide led us on a clear path for a quarter of a mile, then bushwhacked through ankle-deep marshland. Deep in heavy foliage, Gii pointed his machete at a shattered dish and water can, all that remained of a Japanese field hospital. The air was hot and damp, and the site swarmed with mosquitoes. I could imagine what it must have been like to be a wounded Japanese soldier trying to recuperate at the makeshift infirmary. The Japanese lost 24,600 men—from a force of 30,000—trying to hold on to Guadalcanal and Tulagi.

Southerland walked for three days through this jungle, evading Japanese soldiers, until he reached the coast and sought the help of villagers, including 15-year-old Bruno Nana, who guided Southerland to the Americans. We visited Nana, who still lives on the island, and he talked to us about working for the Japanese during the occupation, laying communication lines. Nana told us that on August 6, 1942, the night before the U.S. invasion, "a German working with the Japanese warned us that the Americans were coming. So I left for my village." At dawn, the villagers saw ships in the sound and evacuated to higher ground. "We watched the landings and planes coming in," Nana said. "Boom, boom! We saw the whole thing from the hills."

Following Gii as he hacked his way through saw grass, we began working our way up some 500 feet to the rim of an ancient volcano. The ridge formed an almost complete circle but opened on the side facing the sea.

"This ridge," Taylan said, "is the one Sakai mentions in his account." He pointed at an island to the northeast. "The dogfight began over Tulagi, and descended lower and lower in this direction." After delivering the fatal blow to Southerland's Wildcat, Taylan said, "Sakai almost hit this ridge during his pullout."

I asked where the Wildcat wreckage was from our position, and Gii pointed into the crater.

Bushwhacking through sharp grass, we slipped and skidded down the incline. At one point, we began a traverse down a sheer dropoff, with the heavily laden

RALPH WETTERHAHN (2)

Islander Edilon Gii (left) surveys the saw-grass-covered ridge near the wreck he found in 1998. The Navy bureau number identified the remains as James Southerland's F4F, shot down in 1942.

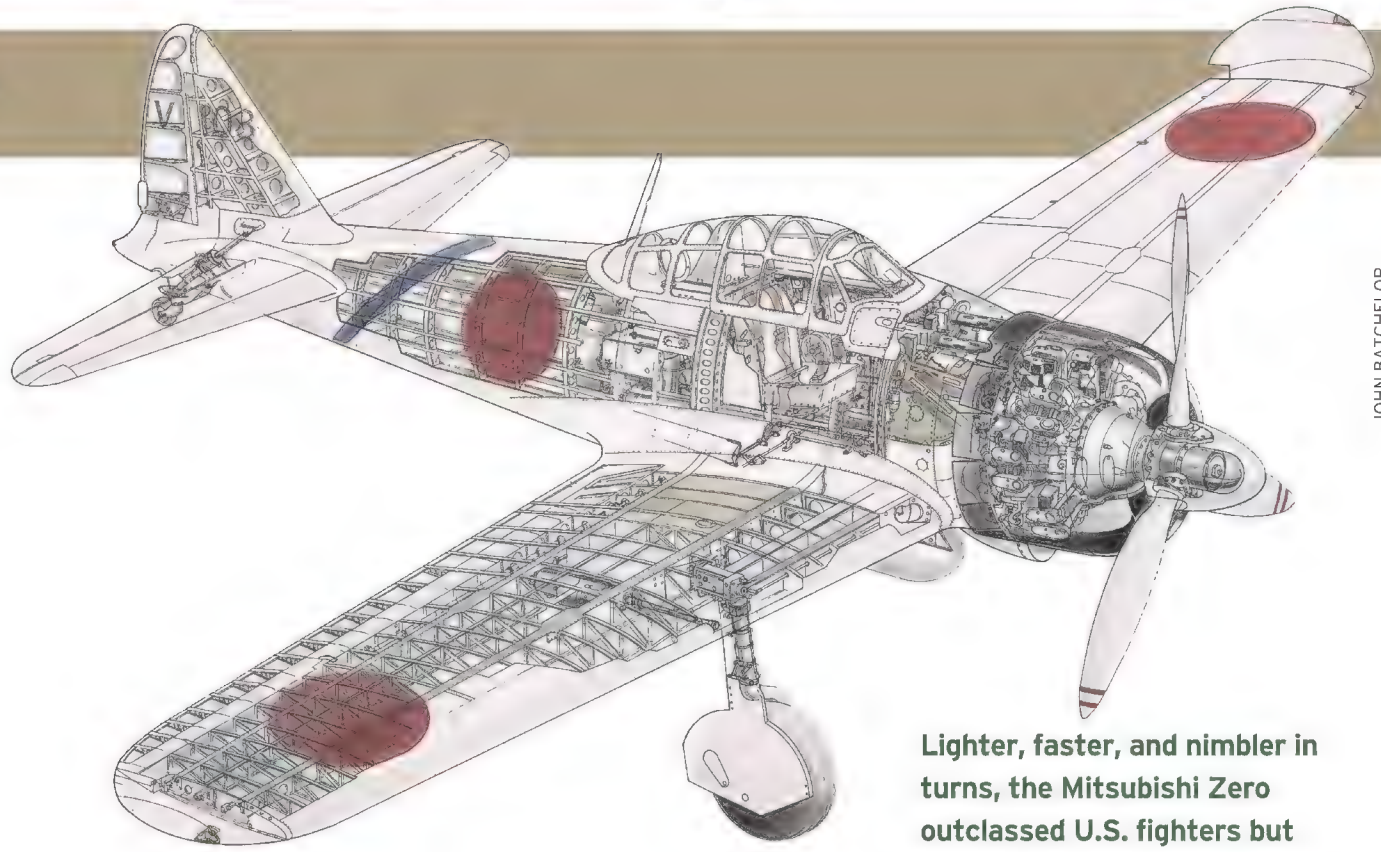
NAVAL HISTORICAL CENTER 80-G-17066

In August 1942, Japanese Betty torpedo bombers flew through flak and anti-aircraft fire to attack the Navy fleet.

cameraman showering me with loose rocks, mud, and branches from above and behind. No footholds would support full weight. With a bare hand, I clawed muck from around a vine root and gripped it, and with the other hand grasped a dangling vine. Its thorns cut my hand like razor wire. Working my way from handhold to hand-hold, I tried not to think about how we were to eventually get back out.

After about 20 minutes of snail-pace descent, we reached firmer though still steep terrain, and from there eventually reached the bottom of the crater. There, at a twist in a stream, we found the first piece of wreckage, a bullet-riddled aircraft

THE DOGFIGHT



JOHN BATCHELOR

Lighter, faster, and nimbler in turns, the Mitsubishi Zero outclassed U.S. fighters but carried no armor for its pilots.

WHEN HE FOUND the 27 G4M1 Betty bombers about to attack the 50 U.S. Navy ships off the coast of Guadalcanal, Lieutenant James J. Southerland II radioed his division, "Drop belly tanks, put gun switches and sight lamps on." Then he added, "Let's go get 'em, boys!"

The Betty, with its 81-foot wingspan and 1,100-gallon wing tanks, had exceptional range. It also had a vulnerability: Without self-sealing fuel tanks, the airplanes easily caught fire when hit. To compensate, the Japanese armed the aircraft with 7.7-mm machine guns in the nose, top turret, and mid-fuselage, and one 20-mm cannon in the tail. A Betty's gun crew could launch a hail of bullets at any attacker.

Southerland and his division tore through the Betty formation. As he maneuvered, he reported later, he saw "the open bomb bays, and it looked as though a total of eight to ten medium bombs were lined up fore and aft on either side of the one plane noted in particular. I hit this plane at the forward end of the bomb bay from below and at close range." Flames burst from beside the left engine. The bomber rolled seaward and crashed. It was the first aerial victory over Guadalcanal.

That day the bombers were escorted by 17 Mitsubishi Zeros, flown by Japan's most experienced fighter pilots. Three Zeros now turned on Southerland. As the first made a firing pass, Southerland broke left and down. His airplane was hit but still responding. He spotted another bomber; he reversed and poured .50-caliber ammunition into it while taking more hits from the bomber ahead and fighters on his tail. His windscreen was cracked, and smoke and oil made its way into the cockpit. The gun panels on the upper surface of his left wing were blown off. Each time a Zero opened fire, Southerland crouched behind his cockpit armor. Each time his altitude fell lower and lower, but with every pass, the overshooting Zero provided a fleeting target and Southerland took a shot — until his guns quit firing. He tried the manual recharging handles but to no avail; 7.7-mm slugs clanged against the armor plate behind him.

Well above the action, Saburo Sakai watched the drama unfold. His biographers later wrote that he was amazed at the Wildcat pilot's skill at eluding his attackers and his ability to fight back effectively.

By now Southerland was running out of options. Near the island of Tulagi, he pointed his aircraft's nose toward Guadal-

engine bathed in shafts of sunlight.

Thunder echoed off the crater walls, and it began to rain. Swatting mosquitoes, I contemplated the danger of a flash flood and scanned the crater above our location. I saw a deep slash mark about 100 feet up the side of an immense hardwood tree. The scar looked like one that might be made by a spinning propeller. Just beneath it jutted aged splinters where a hefty branch had been broken off. The airplane had likely struck the tree at low velocity, probably in a spin. Had the Wildcat been flying when it hit, the debris pattern would have been in the shape of a triangle, wreckage fanning outward from the point of impact. But the engine poked from the stream bed within yards of the impact scar, and aircraft debris was scattered in all directions. We also realized that storms and floods had surely redis-

RALPH WETTERHAHN (2)

Preservationist Justin Taylan (at left) with Gii. Trucked from the jungle to Guadalcanal's Vilu War Museum (right): a ravaged Lockheed P-38.

AFTER DELIVERING THE FATAL BLOW TO SOUTHERLAND'S WILDCAT, TAYLAN SAID, "SAKAI ALMOST HIT THIS RIDGE DURING HIS PULLOUT."

canal and friendly lines. "My plane was in bad shape," he later wrote, "but still performing.... Flaps and radio had been put out of commission." Though his goggles were shattered, Southerland somehow noticed a fourth Zero appear. Sakai had joined the fight.

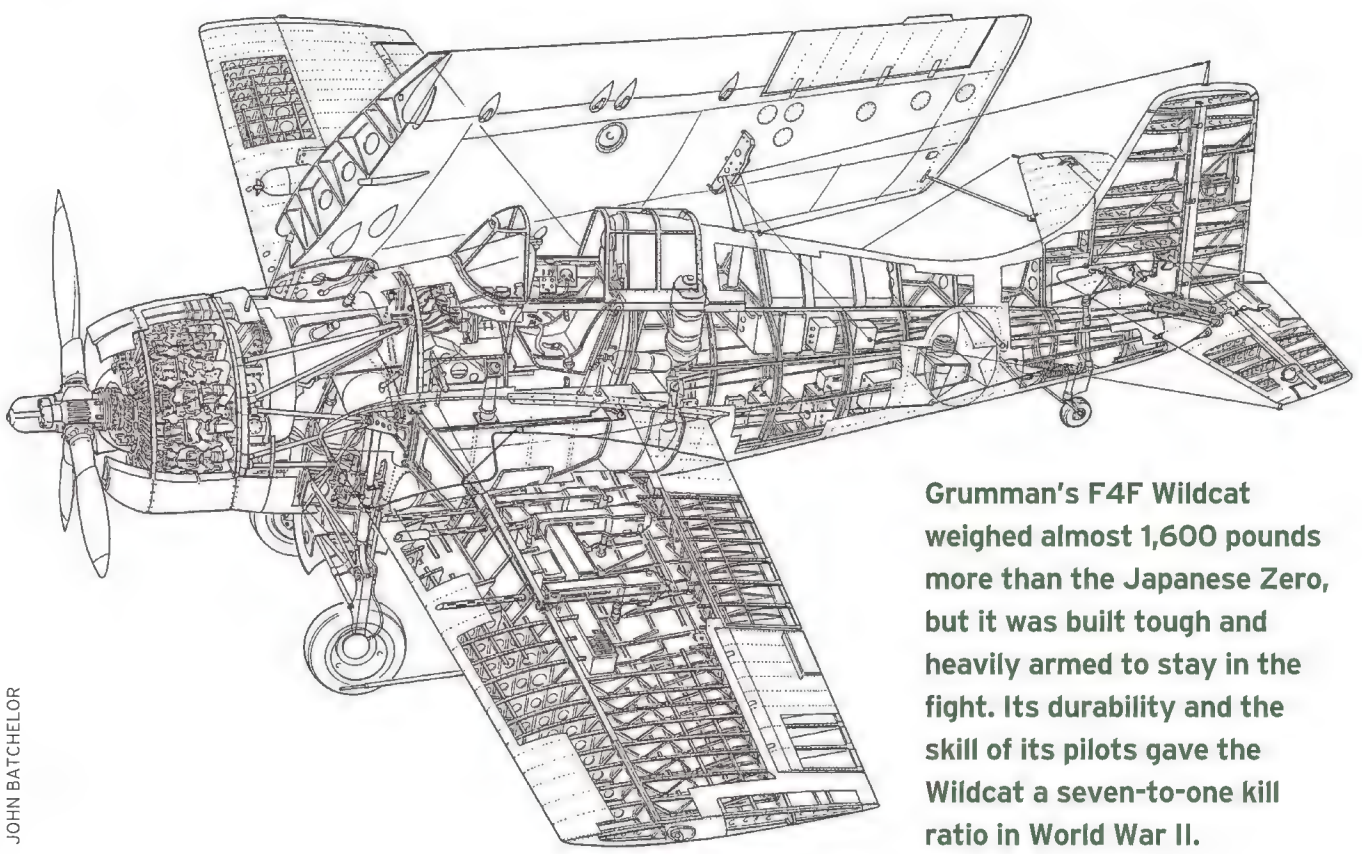
Instead of making high-speed passes, Sakai decided to latch onto the Wildcat's tail, matching turn for turn while slowly closing the distance. By this time the dogfight had shifted over land, where villagers watched the struggle above.

To Sakai's surprise, the Wildcat suddenly leveled out. Sakai reached for his camera and snapped a photo, then fired a long burst of 7.7-mm rounds at Southerland, to no apparent effect. Sakai shoved his throttle forward to get closer and saw the Wildcat's rudder "ripped to shreds, looking like an old torn piece of rag." Distracted, Sakai found himself gliding in front of the Wildcat. He snatched the throttle back – too late. Sakai cringed at his mistake, but the Wildcat pilot did not fire.

Sakai slid back, stopping his deceleration as the two planes came wingtip to wingtip. The American pilot had already shoved his cracked canopy aft. Sakai did likewise. He watched the man, his flightsuit covered with blood, undo his harness. Southerland remained huddled over, busy in the cockpit as Sakai maneuvered behind the Wildcat. "There was no reason to aim for the pilot again," Sakai later wrote. "I wanted the airplane, not the man." He set the target in his gunsight and pressed the 20-mm switch on the throttle. Rounds struck the Wildcat engine cowl.

A few minutes later, a bullet from a Douglas Dauntless struck Sakai just above the right eye, penetrated his skull, and exited out the back. Knocked unconscious, Sakai recovered his senses low over the water and undertook an extraordinary five-hour return to Rabaul.

Southerland made it to safety and returned to action, becoming an ace. He died in a crash off the Florida coast near Jacksonville in 1949. Sakai eventually recovered from his wound and also returned to combat. He died in 2000.



JOHN BATCHELOR

Grumman's F4F Wildcat weighed almost 1,600 pounds more than the Japanese Zero, but it was built tough and heavily armed to stay in the fight. Its durability and the skill of its pilots gave the Wildcat a seven-to-one kill ratio in World War II.

tributed the wreckage since crash day.

I studied the engine. One propeller blade was still attached to the prop housing. Bent back at the tip, the blade showed signs that the engine was still pulling power at impact. Side by side near the tip were two bullet holes. One most surely was from a 7.7-mm round, the type fired by the machine guns on Zeros. The second, a larger hole, had been made with a round possessing significantly more energy. Too small for a complete 20-mm round, it most likely was caused by a fragment or ricochet of that higher-caliber shell, which Zero pilots fired from two cannon. There was an "exit wound" flare to the metal on the front of the blade. Both rounds had pierced the blade from behind: The shooter, or shooters, had been chasing the Wildcat. The evidence was consistent with what both Sakai and Southerland had reported: that Japanese Zero pilots had flown firing passes behind the Wildcat.

The Pratt & Whitney R-1830 engine is an air-cooled radial with two rows, or banks, of seven cylinders each. One cylinder on the rear of a bank had been heavily damaged, though the cylinder forward and to the right (they are offset so that one does not block the air from reaching another) showed no apparent distress other than from exposure to the elements.

The shell casing that solved the mystery of Southerland's last moments in the air. It had been pierced by a round from a Betty's gunner and the explosive had detonated, jamming Southerland's gun.

NASM (SI NEG. #9A00199)

Wildcats were dispatched in divisions of four to protect their aircraft carriers and other ships from Japan's medium bombers. Southerland led a division from the USS *Saratoga* on August 7, 1942, and was joined by another. Of the eight pilots, five returned.

Damage to the rear cylinder almost had to be from heavy weapons fire striking it from behind. The top of the cylinder, including the cooling vanes, was missing. A Zero's 20-mm round could have blown the top off that cylinder, and as I examined the pushrod that had been attached to a valve that was now gone, I realized that Sakai had, as he'd said, spared Southerland. After arming his 20-mm, he aimed for—and struck—the engine. He could have easily aimed for the cockpit.

Moments prior to his bailout, Southerland had an opportunity to shoot Sakai down: The Japanese pilot overshot after a firing pass. Why did Southerland, who had already shot down two Japanese aircraft and out-maneuvered several others, not take advantage of Sakai's error? He reported that he had tried to fire but had been unsuccessful. Was he out of ammunition, as he himself surmised, or had his guns jammed, as author Sakaida believed? Southerland said he had tried to clear the guns with the recharge mechanism mounted in the cockpit and still had been unable to shoot.

Taylan had seen a wing section on his first visit. A look at the machine guns mounted in the Wildcat's wing might hold the answer to what had prevented Southerland from firing.

We moved west, up the stream, past thick concentrations of uprooted tree trunks, brush, and debris that presented clear evidence of flash flooding. Rain continued to pour. I wondered how much

RALPH WETTERHAHN (3)

The author and the propeller from the F4F's Pratt & Whitney R-1830 engine. The two 7.7-mm holes in the propeller tip were almost certainly made by the gun of Saburo Sakai. Below: Southerland's revolver.

ONE BLADE WAS STILL ATTACHED TO THE PROP HOUSING. BENT BACK AT THE TIP, THE BLADE SHOWED SIGNS THAT THE ENGINE WAS STILL PULLING POWER AT IMPACT. NEAR THE TIP WERE TWO BULLET HOLES.

time we might have to scramble up the slope once we heard the rush of floodwater. My thoughts were interrupted by the sight of the top half of a main landing wheel protruding from the stream bed. Taylan remembered the wing was located uphill from that point. The climb was so strenuous that at one point I turned around, deciding that the route was too hazardous to continue, but Canadian photographer Larry Quesnel, with a 27-pound camera balanced on one shoulder and 30 more pounds strapped to his back, slipped past me and took on the ascent like a mountain goat. In another 200 feet, we came upon a wingtip. Gii, ahead on the slope, called down that a landslide had covered the rest of the wing with dirt. There was no hope of digging down to the wing and no hope of studying the wing-mounted guns. We decided to search the area for ammunition.

It was Gii who found the shell casing. When he held it up, my heart sank. The bullet tip was gone. A spent round was not what I was hoping for. Gii handed it down anyway, and I peeled away the muck. It was a .50-caliber, but what really interested me was that a section of linkage belt was attached. Linkage is stripped away and jettisoned as each round enters the gun barrel chamber. The fact that linkage was still attached to this round meant that it hadn't been fired.

I cleaned away grime from the end of the shell. The primer showed no evidence of a firing pin's impact: more evidence the round had not been expended. Then I turned it over and let out a whoop. The shell case had been dented—pierced—at the midpoint. Whatever struck the case had hit with high energy. Southerland reported taking fire both from the gunners on the Betty bombers he was chasing and from the Zeros defending the bombers. One bullet, he said, had cracked his bullet-proof windscreen. Other hits blew open the panels on the top of his wings through which armorers loaded the guns.

Gii's find had been significant: It proved that at least one of Southerland's guns still had ammunition.

At that point, we were about halfway up the western slope of the ravine. To return, we decided to continue upward, then make our way back across the ridge top. As I sucked in great breaths of air, any lingering questions I'd had about how the wreck had remained undiscovered for so many decades were erased.

Back at the King Solomon Hotel in Honiara, Guadalcanal's capital, I placed a 7.7-mm round against the indentation and puncture hole in the .50-caliber shell Gii had found. It fit nicely. Because of the angle at which the tip of the round fit best, the round appeared to have arrived from ahead of the Wildcat. The casing most likely had been damaged during Southerland's attack on the Betty bombers, but why was the bullet missing? I noticed that the casing was flared at its end. The flare shape of the neck indicated that this round had detonated outside the gun barrel. In piercing the casing, the 7.7-mm round had ignited the gunpowder; that's why the bullet was gone.

Above the impact point on the casing, the linkage belt had been cracked by the same projectile that had continued on to pierce the casing. The combination of a round that had "cooked off" and a damaged belt had almost surely caused a jam within the ammo box or at the point where the round was to enter the feed channel. Sakai probably owed his life to the Betty crewman who had shot that 7.7-mm round. Taylan gave the casing to the National Museum in Honiara.

The following day, Gii went back alone to the site, this time in search of the cockpit. I was certain it was somewhere near the impact point. It may seem like a minor task to search for a cockpit in a two-acre area, but in that terrain the task is daunting. Gii didn't find the cockpit, but he did discover Southerland's .45-caliber pistol. Southerland reported leaving it behind in the aircraft when he bailed out.

Coming upon a crash site is an eerie experience. Maybe it's the contrast between the stillness of the ruin and the obvious chaos of those final moments. Knowing the story of the dogfight made this encounter even more sobering. When I studied the Wildcat's damaged cylinder, I could feel, across the span of 60 years, Saburo Sakai's dilemma: whether to kill an enemy or to spare a fellow pilot amid the appalling violence of World War II.

How Things Work: Electromag

BY TIM WRIGHT | ILLUSTRATION BY JOHN MACNEILL

GEORGE SULICH STANDS ASTRIDE ONE OF TWO 333-FOOT-LONG STEAM-POWERED CATAPULTS AIMED DOWN THE RUNWAY AT THE U.S. NAVAL AIR WARFARE CENTER IN LAKEHURST, NEW JERSEY.

The catapults, identical to those that launch airplanes aboard Navy carriers, are used to tweak and test the 1950s launch technology. But Sulich's interest lies a few steps away, in a concrete-and-steel trench more than 300 feet long, where a new catapult, also aimed down the runway, is under construction. When complete in 2008, it will be the first catapult to use electromagnetics to launch manned aircraft.

As the Navy's project manager for the Electromagnetic Aircraft Launch System (EMALS), Sulich's task is to move the newest catapult technology from development at the research facility to ships at sea. A key instrument in the transition is the 1:12-scale model of an electromagnetic catapult, bolted to the concrete floor inside the lab. In place of a ship's deck, the model is embedded in a knee-high metal casing about 60 feet long, with a narrow slot a few inches deep that runs along the top. An aluminum block rests snugly in one end of the slot. If an aircraft were part of the model, its nosewheel landing gear would be attached to the aluminum block. When the power is turned on, a wave of electromagnetic force silently shoots the aluminum block to the opposite end of the model at a speed of 60 mph. After a few keystrokes on a computer, the electromagnetic wave travels in reverse, gently returning the aluminum block to its starting position.

As the 21st century dawns, steam catapults are running out of steam. Massive systems that require significant manpower to operate and maintain, they are reaching the limits of their abilities, especially as aircraft continue to gain weight. Electromagnetic catapults will require less manpower to operate and improve reliability; they should also lengthen aircraft service life by being gentler on airframes.

The amount of steam needed to launch an airplane depends on the craft's weight, and once a launch has begun, adjustments cannot be made: If too much steam is used, the nosewheel landing gear, which attaches to the catapult, can be ripped off the aircraft. If too little steam is used, the aircraft won't reach takeoff speed and will tumble into the water. The launch control system for electromagnetic catapults, on the other hand, will know what speed an aircraft should have at any point during the launch sequence, and can make adjustments during the process to ensure that an aircraft will be within 3 mph of the desired takeoff speed.

The scale model in the Lakehurst lab is a linear induction motor, an efficient way to generate thrust with a minimum of moving parts. Shipboard electromagnetic catapults will be based on larger linear induction motors, made up of three main parts: two 300-foot-long stationary beams, or stators, spaced a couple of inches apart, and a 20-foot-long carriage, or shuttle, that is sandwiched between the two beams and can slide back and forth along their lengths.

Each beam is made up of dozens of segments. Running down the spaces alongside the two beams, in sealed housings, is the wiring needed to energize them and turn them into an electromagnetic force to propel the carriage. Selectively turning on and off each beam's segments generates an attractive magnetic force at the carriage's leading edge and a repulsive magnetic force at its rear. At no point are all the beam's segments simultane-

PH3 JASON A. FULTS/US NAVY

Steam-powered catapults, expensive and difficult to maintain, are operating near their limits and will not be able to accommodate heavier aircraft planned for the future.

netic Catapults

ously activated; instead, only those segments near the moving carriage are energized, creating the effect of a magnetic wave.

The interface between carriage and airplane runs through the aircraft's nosewheel landing gear, using the same hardware employed by the current steam catapult system. After hooking up to the carriage, aircraft are electro-magnetically pushed and pulled down the catapult until airborne. After releasing an aircraft at speeds approaching 200 mph, the carriage will come to a stop in only 20 feet, its forward movement countered by reversing the push-pull electromagnetic forces of the two beams. The same energy is then used to return the carriage to its starting position.

An electromagnetic catapult can launch every 45 seconds. Each three-second launch can consume as much as 100 million watts of electricity, about as much as a small town uses in the same amount of time. "A utility does that using an acre of equipment," says lab engineer Mike Doyle, but due to shipboard space limitations, "we have to take that and fit it into a shoebox." In shipboard generators developed for electromagnetic catapults, electrical power is stored kinetically in rotors spinning at 6,400 rpm. When a launch order is given, power is pulled from the generators in a two- to three-second pulse, like a burst of air being let out of a balloon. As power is drawn off, the generators slow down and the amount of electricity they produce steadily drops. But in the remaining 42 seconds between launches, the rotors spin back up to capacity, readying themselves to release another burst of energy.

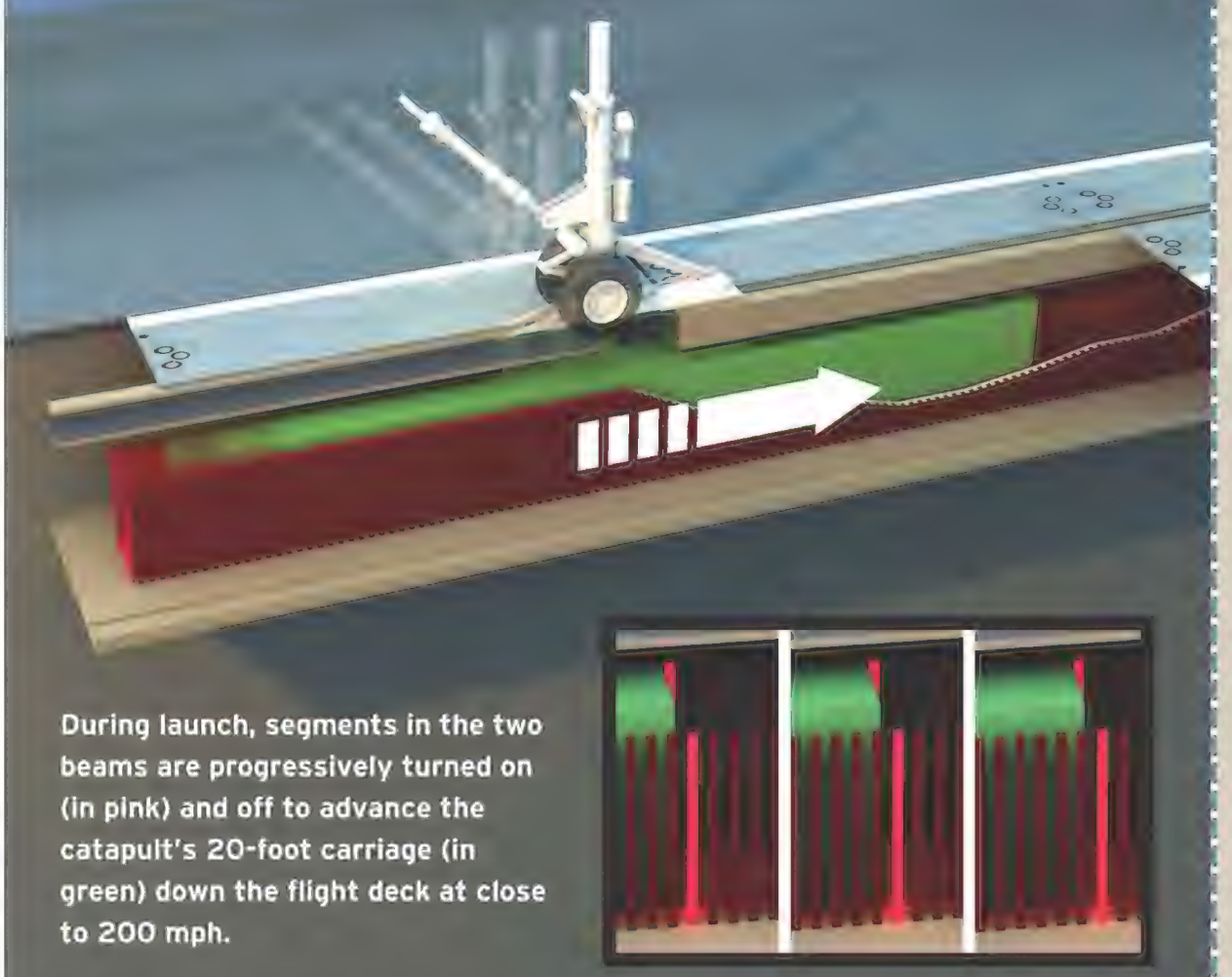
Working from the scale model in the Naval Air Warfare lab, designers developed the electronic hardware and software needed to build an EMALS prototype, which can accelerate dead-weight test articles (massive metal frames on wheels) to 165 mph in three-quarters of a second on a track just 100 feet long.

Care has been taken to make the launch process as similar as possible to current steam systems to help launch crews ease into the new technology. Pilots, as they position their aircraft for a catapult shot, won't be able to tell if they are launching with electromagnetics unless they happen to notice the absence of steam escaping from the deck.

Electromagnetic catapult technology already has the ability to launch any aircraft now in the Navy inventory and any the Navy has ordered. With the new launch system's potential to achieve acceleration forces reaching 14 Gs, human endurance may be one of the few limitations it faces.

A Whole Lot of Pushing and Pulling

Key to the U.S. Navy's new catapult is the linear induction motor, which consists of two 300-foot-long beams (in red), and an aircraft-bearing carriage (in green) that rides back and forth between them. When the two beams are energized, electromagnetic forces push and pull the carriage forward, creating a thrust strong enough to launch the Navy's heaviest aircraft.



During launch, segments in the two beams are progressively turned on (in pink) and off to advance the catapult's 20-foot carriage (in green) down the flight deck at close to 200 mph.

Ever fantasized about building your own airplane? Even one of the least expensive kits from leading manufacturer Van's Aircraft, the RV-9A, equipped with the most modest options—a used, 118-horsepower engine, a wood propeller, and simple interior furnishings—would cost "somewhere in the high $30,000 range," says Ken Scott, who oversees tech support and publishing at Van's (and occasionally writes for this magazine). On the other end of the scale, a Lancair PropJet can cost $129,500—not including engine, propeller, avionics, paint, or seats, all of which can easily bring the price close to $1 million.

But if your budget tops out around $10,000, you do have options. A few kits out there fall in your price range: Steve Bennett, owner of kit dealer Great Plains Aircraft in Boys Town, Nebraska, sells an aircraft called the Easy Eagle for $8,000. Or you can build an affordable airplane from scratch.

If you're going to build an airplane for that little, warns Scott, "you have to keep it down to what you absolutely need." Some buyers, he says, "try to imagine everything they can possibly do in an airplane.... It ends up heavy and impossibly expensive."

One of the most expensive parts of any homebuilt is the engine. The Easy Eagle's powerplant, a basic hand-start, single-ignition, 1,915-cc VW engine, goes for $3,620, including the carburetor but not the exhaust system. "The Volkswagen conversion engine seems to be the best bang for the buck," says Pat Panzera, editor and publisher of *Contact!* magazine, which covers kitplane and homebuilt powerplants. "Mostly because it can go direct-drive"—the propeller is bolted directly to the crankshaft and turns at the engine's rpm.

There are cheaper powerplants, but builders will end up spending more because they will have to buy a propeller speed reduction unit, Panzera adds. Car engines run at higher revolutions per minute than aircraft engines; adding the unit slows rpm so the propeller operates more efficiently.

As for the other costs involved in building an airplane for $10,000 or less, we offer two detailed case histories.

CORNELIUS BRAUN (4)

Top: With its sharp, sporty appearance, Bruce King's BK1 doesn't look like it cost only $6,800. Above: King fashioned the tail gear (as well as the nose gear) from lightweight aluminum, saving hundreds of dollars over pre-formed parts.

IN 2004, BRUCE KING of San Antonio, Texas, built his BK1 prototype for only $6,800. The total for the aluminum he used to construct his airframe came in at just over $2,500. He used a VW engine, which he bought from Great Plains Aircraft for $2,170. King's instrument panel cost $1,250 and included the standard elements: airspeed indicator, altimeter, tachometer, oil pressure and temperature gauges, fuel and cylinder head temperature gauges, a GPS AirMap 500

Build This Airplane for 10 GRAND

HOW TO GET FROM THE DOLLAR STORE TO THE RUNWAY.

by Bettina H. Chavanne

The BK1's instrument panel components totaled $1,290. Right: At more than $4,000, the engine-propeller combo was the BK1's priciest item.

unit, and an emergency locator transmitter.

King's first homebuilt project was a highly modified Hummel Bird, a kitplane that is usually configured for a person about five-foot-seven and 160 pounds. For the BK1, "I blew it up into a wide-body, heavier version, using the plans [for the Hummel Bird] as my guide," says King. He put in a full-size, four-cylinder VW engine (the Hummel Bird is designed to hold a VW engine with only two cylinders) and constructed a new wing and tail section. King ended up with an aircraft with a 400-mile range (and an hour reserve) at a speed of 130 mph, and room to carry a pilot six-foot-four and 240 pounds, with a suitcase weighing 30 pounds.

He flew the BK1 from San Antonio to last summer's Experimental Aircraft Association fly-in at Oshkosh, Wisconsin. (The 53-year-old organization was founded with the mission of bringing together people who want to build their own aircraft.)

"Some of my best experiences have been stopping at little airports," says King of his cross-country adventures in the airplane. He hopes to sell the plans for his aircraft's design through his company, BK Fliers.

For his $7,500 KK-1, Ken Scott made fuel gauges (above) from about 50 cents' worth of tubing and a few aluminum elbow fittings.

LAST YEAR, KEN SCOTT, who lives in Canby, Oregon, partnered with designer Ken Krueger to create the KK-1. His total cost: $8,500.

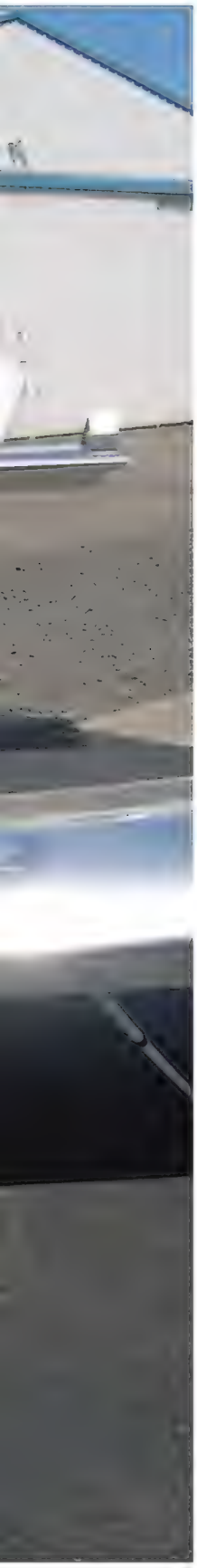
Scott purchased wheels and brakes from Great Plains Aircraft for about $500 and a canopy bubble from Airplane Plastics in Tipp City, Ohio, for $800.

He built his own 60-horsepower Volkswagen engine derivative for about $2,800. "It doesn't turn out a lot of power," says Scott, "so the airplane has to be pretty small." For the airframe, he used the cheapest material he could: riveted sheet metal.

The radio stack, comprising a used GPS unit and a handheld radio purchased on eBay, cost him $480. The basic configuration Scott chose is fairly common for kitbuilders. "I know where I am to within about eight wingspans on the surface of the planet, and I can talk to anybody, so how much more do I need?"

Because he does not have a transponder, Scott does not fly in airspace where one is required. He says he uses his homebuilt to "commute around the valley, visit friends, take it out to breakfast, or just go up and look at the sky."

Scott hopes the duct tape reduces excess cooling airflow to the engine. Also thrifty: Putting your kid to work. Scott's designer, Ken Krueger, enlisted daughter Amy (opposite).



KEN SCOTT (4)

The KK-1's seats (below) have flown in three airplanes. "They're ugly, stained, and cheap," Scott says.

For Do-It-Yourselfers

Experimental Aircraft Association
3000 Poberezny Road
Oshkosh, WI 54902
(920) 426-4800
www.eaa.org

www.homebuilt.org
"Currently available kits and plans," plus information on vendors, literature, clubs, and more.

www.homebuiltairplanes.com
A forum for homebuilders to exchange information.

www.kitplanes.com
Kitplanes magazine's Web site, offering articles and back issues, product reviews, a list of "support groups," and newsletters.

www.exp-aircraft.com
Lists more than 260 aircraft companies, plus classifieds, how-to articles, and a searchable vendor site.

www.kitplanesbooks.com
For those who prefer their information in book form.

OUTSIDE OF THE COSTS, WHAT ELSE do you need to consider before you build a low-cost aircraft? Great Plains' Web site, *www.greatplainsas.com*, includes a list of questions prospective homebuilders need to ask themselves. For example: How much time can you dedicate to completing your airplane? Steve Bennett estimates most people spend between 300 and 400 hours annually, and that it would take 300 to 500 hours to complete his Easy Eagle. And think about the workspace you have (and how much it will annoy your family if you take it over).

You also need to be honest in assessing your skills: Do you have a knack for woodworking, metalworking, or sewing? (The Easy Eagle, for example, has a steel-tube fuselage and fabric-covered wood wings.)

Then there is temperament. The people who have what it takes "are clever, crafty individuals," says Panzera, "the type of people who would rather build something themselves than pay someone to do it for them." Or people for whom hunting down a cheap radio stack on eBay is as much fun as tinkering with a conversion engine in the garage.

475

Seconds after a British Airways Boeing 747 touches down with a puff of burning rubber, Pete Wooldridge and Jim Davison pull onto one of two runways at London's Heathrow International Airport in a yellow and orange sport utility vehicle. Their job is to inspect the pavement for debris, cracks, or anything else that could perturb a jet traveling at 100 mph. But as they cruise down the centerline, it's tough to ignore the view through their windshield: five airliners lined up on approach, all speeding straight at them.

Then the control tower radios orders: Vacate the runway. Wooldridge hits the gas and twists the wheel like he's dodging a semi. The SUV lurches off the pavement at about 50 mph and jounces across the grassy shoulder as the tires of a Jet Airways Airbus A340-300 from India slam onto the runway, the airliner thundering past.

This is life at Europe's busiest international airport, where the twin runways are some of the hardest working expanses of concrete on Earth. No other major airport moves so many airplanes and passengers through so little space, with so little time to spare. Any holdup reverberates around the world. Competition for landing rights is so fierce it's the crux of international treaty negotiations (see "Finding a Place to Land," p. 49).

But the cramped and crowded airport is in a battle for its future. Paris, Amsterdam, and other European airports boast more runways and space to handle the rising demand for air travel. Their flight schedules are growing while Heathrow is maxed out, hemmed in by residential areas and neighbors complaining noisily about noise.

The government's response to the overcrowding is to float plans for giving Heathrow another runway, which would mean bulldozing centuries-old English villages off the map. People from surrounding villages promise, quite matter-of-factly, that before this happens, they will paralyze the airport with protests and lie in front of bulldozers. It has become, for Londoners, a kind of referendum on the future of commercial aviation: Unfurl new runways for an ever-expanding stream of global jet traffic that now has Heathrow bursting at the seams, or lay down limits on how far it can grow.

"The airport was a friendly employer years ago," says Bryan Sobey, who started work at Heathrow as a young customs officer when the aircraft parked at the gates were Boeing Stratocruisers and Lockheed Constellations. He retired as a manager 15 years ago, and lives with his wife, Ann, in a working-class rowhouse just north of the airport. The windows are triple-paned and the walls lined with Styrofoam panels to mute airplane noise. His cluttered living room, with paintings of trains, bowling trophies on the walls, and cards celebrating the couple's 55th wedding anniversary, sits where check-in desks and shops are to be located in a new terminal for the planned runway. Today, Sobey says, Heathrow is "like a dragon breaking out of its egg. It's become an object of threat, really."

RAF Heathrow

The airport began amid shady maneuverings near the close of World War II, when Winston Churchill's government used wartime powers to seize a small private aerodrome and a vil-

ABOVE: KATSUHIKO TOKUNAGA/AVIATIONIMAGES.COM; OPPOSITE: PYERS EASTON

Takeoffs and Landings a Year

THE INTRICATE CHOREOGRAPHY REQUIRED TO KEEP HEATHROW RUNNING SMOOTHLY.

BY MICHAEL MILSTEIN

lage called Heath Row for a Royal Air Force base to supply troops in the Far East. But Harold Balfour, Churchill's undersecretary of state for air, later admitted that was only a ploy to get control of the prime land, 12 miles west of Victoria Station, for London's main commercial airport.

No base ever appeared. But Heathrow airport did.

This put what would turn into the world's most bustling international airport smack in densely populated West London, the first of what two top British planners called "a series of minor planning disasters that together make up one of the country's truly great planning catastrophes." An early scheme would have permitted the airport to grow by adding more runways to the north, the same location where the unpopular new runway is now proposed to go. But funds ran short, and in 1952 the scheme was dropped. Airport neighbors sighed with relief, and construction began on houses like Bryan Sobey's.

So the airport grew without much of a plan at all. When flying became more affordable in the 1970s—round-trip tickets between London and New York in the 1950s cost more than $4,000 in today's dollars—terminals popped up one by one, crammed between a nexus of runways and taxiways originally built in a Star of David pattern. The cheaper and more popular air travel became, the more Heathrow grew; new concourses inched like tentacles from the airport's center onto the taxiways and runways. Eventually, they left only two parallel east-west runways that today send airplanes over the most populous parts of Europe's second largest city.

The Air Traffic Two-Step

A 1978 government report estimated Heathrow's capacity at 275,000 takeoffs and landings a year. Today, it manages about 475,000. The runways handle 1,370 takeoffs and landings in a day—up from 1,290 in 1995—all with no new pavement. They haven't been widened or lengthened. But controllers have found ways to squeeze more aircraft onto them.

Air traffic controllers pride themselves on each week's takeoff and landing stats—with number of minutes' delay—which are displayed on a scoreboard-style readout in the air traffic cen-

Opposite: Airliners are packed cheek-to-jowl on Heathrow's cramped taxiways. Above: The airport, hemmed in by densely populated neighborhoods, simply has nowhere to grow.

ter's lobby. Martyn Jeffery recalls Heathrow's record like a proud father. He is Heathrow's general manager for National Air Traffic Services, once a government agency but now a private company that manages air traffic. The date was September 22, 2005: 48 arrivals and 52 departures in an hour—slightly less than one a minute.

Heathrow has gone 34 years without a major accident. The last was a British European Airways Trident that crashed just after takeoff in 1972, killing all 118 aboard. It was the nation's worst air disaster—that is, until the bombing of a Pan Am 747 over Lockerbie, Scotland, in 1988. Collisions have happened—on the ground. At least three times since 2004, airplanes jostling for position on busy taxiways have bumped wings or rudders. In 2005, the crew of a United Airlines 777 that struck an Air Jamaica A340 while heading for a takeoff holding spot suggested the Airbus was closer than it would be at other airports. But investigators said, "This was not considered unusual for Heathrow."

One of the trade secrets of Heathrow's air traffic controllers is that they don't think about the people. They focus on the airplanes, because considering the hundreds inside every one—sipping their complementary sodas and worrying about their connections—would rapidly overwhelm anyone, says Mark Hewitt, a control tower supervisor.

A trick to making the most of Heathrow's runways comes clear in the routing of inbound airliners. They go first to one of four beacons at each corner of the airport, where they circle in stacks—each one 1,000 feet above the other—waiting for controllers to direct them in. For passengers, it's frustrating. For controllers, the stacks supply a constant reservoir of airplanes to put—rapid-fire—onto the pavement. The steady stream of airplanes from the stacks guarantees the runways never go idle.

Heathrow's schedule is so full that if the runways stand empty for even a moment, millions of dollars' worth of landing time will be lost.

"Once it's gone, it's gone, and you'll have a delay through the rest of the day that you cannot recover from very easily," says Martin Alder, a former air traffic controller and pilot who recently retired from flying British Airways 747s and A320s in and out of Heathrow. "The only way it can work to the levels it does is uniformity."

The stacks also give controllers a choice of airplanes. A big 747 trails powerful tornado-like vortices from its wings, so a smaller Airbus A321 cannot follow as closely. Faster airplanes catch up to slower ones. Airliners flying against the wind touch down at a lower speed so they can turn off the runway faster. Controllers deal a landing lineup out of the stacks based on all these factors, packing airplanes as close as safely possible.

The dealing is done deep within a dull concrete building a few miles north of Heathrow, in a room the size of a small gymnasium, called the London Terminal Control Centre. Controllers at screens along both sides of the room watch over some of the most congested airspace on the globe, handling all airplanes below 24,500 feet flying to and from Heathrow and domestic airports Gatwick, Stansted, Luton, and London City. Today Andrew Garrett has one of the hottest seats in the room. He is the Heathrow director, guiding much of that airport's incoming traffic.

Right now, his green-glowing screen shows problems: The northern stack, which collects airplanes from Central Europe, has turned into a snarl as pilots wheel around thunderstorms.

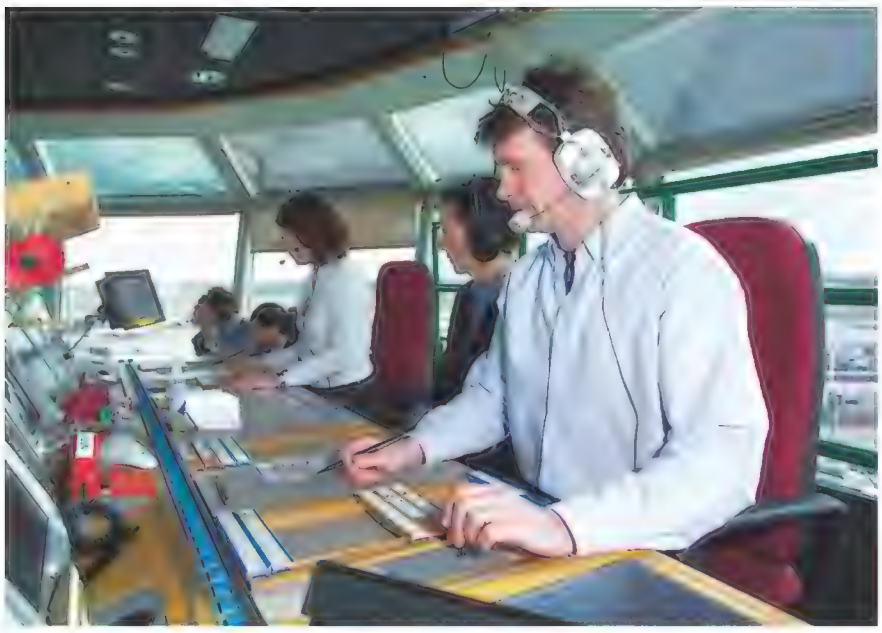
The landing rate has dropped from the usual goal of 45 airplanes an hour to about 35, troubling Garrett like too few RBIs would a cleanup hitter. Instead of three miles apart, airplanes entering the stack are about four miles apart, which to Garrett means wasted time. It also means airplanes showing up from around the world stack up faster; monitors in the center of the room show how many minutes each one is behind its estimated time of arrival.

He spots an Alitalia flight from Milan and sees a chance to shave off some time. It's bound for a southern stack, but he intercepts it. Telling the pilot to turn right, Garrett weaves the Airbus A321 between two other aircraft sliding across his screen toward the runway. That puts one more airplane on the pavement this hour.

Up in the Heathrow control tower, controllers—some in their 20s and

NICK HANNA/ALAMY

Because the approach to Heathrow takes jets over downtown London, pilots delay lowering landing gear and using full flaps to minimize noise from the extra turbulence they cause.



COURTESY NATIONAL AIR TRAFFIC SERVICES

Controllers pick up where computers leave off — juggling late flights and cajoling early pilots to slow down.

wearing T-shirts—sort everything out onto the pavement. The tower takes over flights four miles from the airport. By that point, the airplanes are on final approach, as set up by London Terminal Control Centre, so the tower controllers shouldn't have that much to do with the aircraft aside from instructing inbound flights to adjust speed to maintain minimum spacing and keeping an eye on potential missed approaches.

Two ground controllers—airport traffic cops—weave 747s between and among A330s. Multi-lateration radar triangulates on each airplane's transponder signal, showing each as a radar dot while still on the ground—even behind buildings. It helps controllers work them out of dead-end cul-de-sacs amid terminals built for small airplanes like Hawker-Siddeley Tridents but quickly clogged by modern airliners twice as wide.

A jumbo pulling out may gridlock other airplanes for five minutes or more, and start blocking taxiways. Controllers know almost every patch of spare tarmac where they can put airplanes to sit and wait, but, says Phil Layton, Heathrow's air traffic control manager, "There's less and less places for us to hide them."

A fourth terminal was built on the far side of the southern runway when space ran out in the airport center; to reach it, airplanes must scoot across the runway between the takeoffs and landings of others.

HEATHROW FACTS & FIGURES

- Heathrow has half as many runways as New York's John F. Kennedy International Airport and scarcely half the land area, but handles about 35 percent more flights and 60 percent more passengers (67 million last year).
- It's the third busiest airport in the world after Atlanta and Chicago O'Hare, with the least space.
- It absorbs more international travelers than any other airport; about a third of the flights on 747s and other wide-bodies.
- More than a million people fly in and out of Heathrow each week, and the airport operator predicts that number will rise 25 percent by 2015.
- The average rate of takeoffs and landings per hour has increased from 67 in 1981 to about 85 today.

Moving airplanes gets easier at night, when controllers use a touch screen to turn on lights in the runways. Controllers tell pilots to "follow the greens," illuminating a line of green lights along the right path. Red lights across the taxiway mean "stop."

The time between each takeoff is known as a "Heathrow minute," and in the tower, the goal is to shave it to the bare minimum. Jetliners take off as close as a minute apart, as long as they follow different routes so there is no risk of one catching the other. Controllers shrink the minute even further by craning their necks and watching for an airplane's wheels to lift off the pavement. That's when the next aircraft goes.

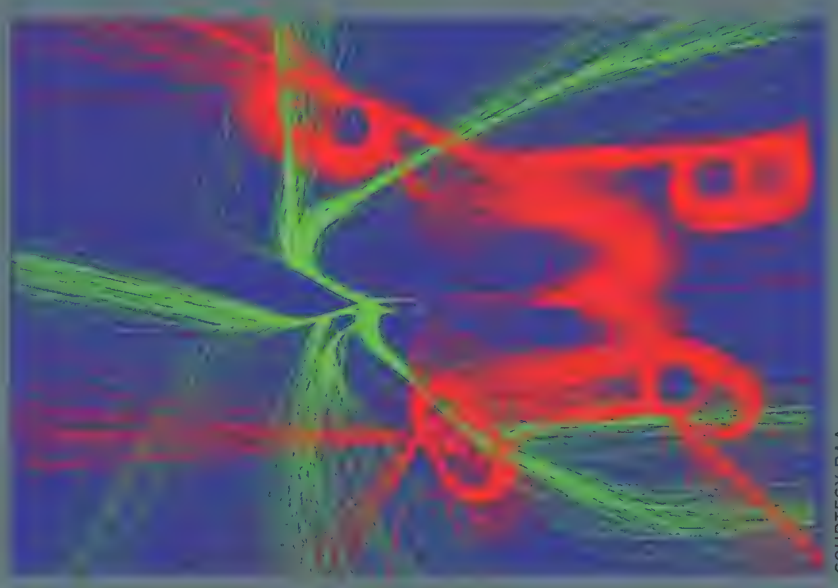
"At Heathrow, we call that a minute," says Paul Hooper, a tower supervisor. Then he grins. "Depending on the airplane, it's probably a bit less than a minute."

It is the most critical timeline at Heathrow. There is a constant campaign to keep pilots from dawdling on the runway; if each airplane throughout the day wastes a few seconds, it adds up to a few airplanes getting stuck when the nighttime flight curfew shuts down nearly all operations. Stephen Mathewson, a former engineering professor who got bored by academic life and joined airport owner BAA as an internal consultant, went to great lengths to measure how fast pilots get on and off the runway. He posted traffic police at the end of the pavement with radar guns to clock the speed of each airplane. Later he turned to ground radar to track each pilot's habits.

Then he crunched the numbers and showed each airline how its pilots were doing. Soon, slowpokes picked up their pace. Virgin Atlantic worked timing into its simulator training. Pilots set their brakes to make better use of high-speed runway exits, which are angled so airplanes can turn off at 50 mph. That adjustment shunts them out of the way faster—arrivals average 50 seconds on the runway. No one wants an airplane poking along, sitting in the way, or braking too late, missing its turn, trundling to the next exit—a time-waster.

All Stacked Up

The red lines represent arriving aircraft, while green lines show departing ones. Approaching airliners join a stack and then fly in an oval pattern, 1,000 feet apart vertically starting at about 7,000 feet, until they are called in to land.



COURTESY BAA

"Most professionals want to behave ably," says Mathewson, who finds himself part efficiency analyst and part psychologist. "You don't need to force them. You just need to raise their awareness that this is an issue, and they can help."

The airport spent about a half-million dollars building a temporary exit next to one closed for eight weeks of reconstruction. Otherwise airplanes would have had to coast 500 feet farther down the runway before turning off, which would slow the landing rate.

Heathrow's new control tower (below) is located near Terminal Three. The control room, mounted on a steel mast, is five stories high and weighs more than 1,000 tons.

"This is the business of teasing the edges," says Richard Smith, a lanky, intense man who helps plan the future of the airfield. He likens Heathrow to a giant aircraft carrier. When he started, after getting turned down for pilot training nearly 30 years ago, 900 airplanes were taking off and landing every day; now 1,370 do. He knows the angle of each taxiway, which affects which way airplanes can turn, which in turn affects how long they take to reach the gates. He knows which airplanes fit at which gates, and how juggling gates at the last second sends ground crews dashing through the airport.

In certain places, 747s park nose-out so their tails do not block signals from the instrument landing system. Workers are tearing down a few gates so the new double-deck A380, the world's

Not everyone is happy about Heathrow's frenetic growth (opposite, left), especially those who live beneath the flight paths. Low-flying jumbo jets (opposite, right) cause vortices that have sucked off roof shingles and shattered tiles.

OPPOSITE FAR LEFT: PHIL WEEDON; LEFT: MARK WAGNER/AVIATION IMAGES.COM

largest passenger airplane, has room to pass (see "Superduperjumbo," June/July 2006). The airport is counting on the airplane to pack in more passengers. But air traffic controllers are starting to scream about all the construction.

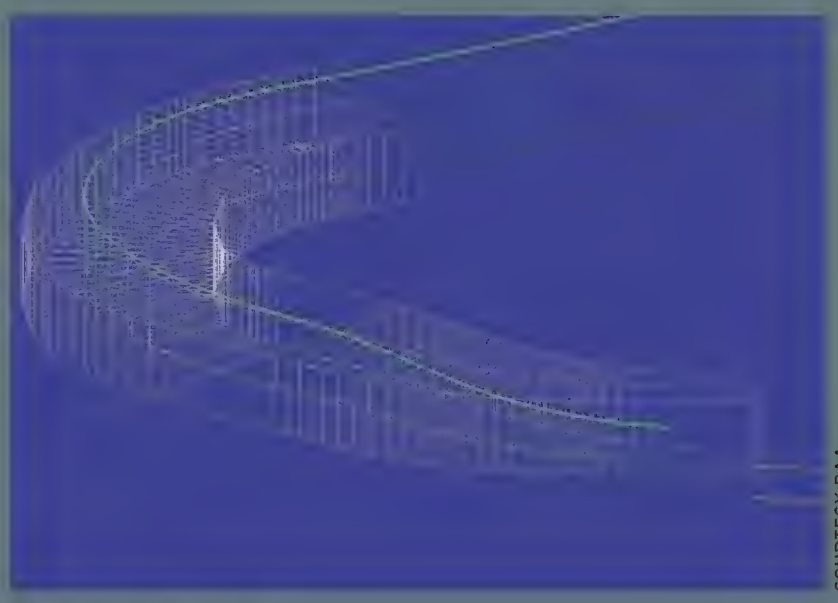
"They have said to us, 'We're getting to the point we can't maintain the movement rate, not because we can't use the runway, but because we don't have the taxiways,' " says Smith, racing around the airport in a white car with a flashing light on top. He eyes a taxiway that is a quilt of concrete patches. "The problem is keeping Heathrow going under all this pressure. We spend huge amounts of time and effort making sure this place doesn't fall over, and it doesn't happen by chance. It works because the place collectively works as a team, by design or by default. And it's not all by design."

An American airliner appears in the rear-view mirror: "I've got to keep an eye on that one," Smith says. "I don't want to get run over by a triple-7." Computers match airplanes to gates, he says, but it's not a simple process: Arab aircraft cannot be parked next to Israeli ones, for example.

Then he sees airplanes parked in a lineup of gates that causes him to chortle: American Airlines 777, United Airlines 777, American 777, United 777, and Iran Air 747. "Well, gee, Mr. Bush! Clearly one of the parameters in the computer is it's okay to put the Iranians next to the Yanks," Smith cackles. "I think that's quite funny."

On any given day, tomorrow at Heathrow has already started. Airplanes are on their way from Hong Kong and beyond, for an arrival the next morning. "Airlines have been told to slow up miles out because there's no use getting here early if we have no bloody place to put them," Smith says. It's practical, and, as far as the passengers are concerned, "Will you notice if the airplane slows down 15 knots, or will you notice sitting on the ground for 20 minutes with the engines running?"

Once the airplanes have landed, Ian Watson juggles them, finding them places at one of Heathrow's roughly 165 gates. The computer may plan out the day, but it can't account for glitches—jetways break, airplanes are late, the weather is unpredictable. So Watson takes over where the computer leaves off, compensating for the unexpected. He works in a bunker-like building in the crook of two taxiways. The building would have a great view of passing airplanes if not for computer screens that block all the windows. Watson uses a joystick to scan every nook of the airport, working out which airplanes get to park at a gate, or pier. Since Heathrow has more airplanes than gates, some park out on the pavement and wait for buses to ferry passengers to terminals.



COURTESY BAA

Shhhhhh

Airlines are fined if aircraft (green line) don't remain within the confines of a noise route corridor (the 3-D white boxes) during takeoff. The aircraft leave the corridor at about 3,000 to 4,000 feet, four miles from takeoff roll.

Finding a Place to Land

AIRLINES THAT HAVE TAKEOFF and landing slots at Heathrow get to keep them, and demand always far exceeds supply. British Airways controls 40 percent of Heathrow's slots, dominating what is sometimes known as "Fortress Heathrow." (You can see the number of slots on any given day at *www.online-coordination.com*.)

There are only two ways to squeeze a new airline in: Enter a lottery for a few slots that no one else wants, mainly odd hours at night, or buy them on a burgeoning gray market for many millions of dollars. In 1991, United and American Airlines paid Pan Am about $35 million per slot pair to take over its routes to Heathrow. In 2004, Quantas paid almost $40 million for two sets of Heathrow slots. At that price, 10 takeoff and landing slots at Heathrow would cost as much as a 747.

For some U.S. airlines, there's a bigger challenge. It's called Bermuda II, a treaty that allows only two airlines from the United States – United and American – and two from the United Kingdom – British Airways and Virgin Atlantic – to fly between Heathrow and the United States.

Delta, Continental, and others would like to fly between Heathrow and the United States, but the treaty won't let them. It's currently under renegotiation, and the result could be an "open skies" treaty that frees up transatlantic routes for more competition, and likely lower ticket prices. Europeans are asking a high price for opening Heathrow. They want the United States to open U.S. airlines to greater foreign ownership, which is restricted by law.

The Bush administration is now trying to loosen the ownership statutes to satisfy European demands. But Jeffrey Smisek, the president of Continental Airlines, has told Congress that even if Heathrow is opened, his airline still couldn't pry its way in. The high price of slots, he said, is "the greatest single impediment to free and fair U.S.-Europe competition."

SØREN GEERTSEN

Airport authorities hope the addition of a 60-gate terminal (above) will alleviate some of the crowding at Heathrow (right). But this terminal will max out eventually too – in 2011 – despite 10 football fields of space on each of five floors.

ABOVE: COURTESY NATIONAL AIR TRAFFIC SERVICES

Neighborhood Relations

About a mile and a half from the end of Heathrow's southern runway is the Hounslow Heath Infant School, a public preschool where cheery Kathryn Harper-Quinn is the head teacher. She loves airplanes. The sleek Concorde, which rocketed in and out of Heathrow until 2003, was "one of the most beautiful things I've ever seen," she says. But the everyday aircraft, descending over the school at slightly less than one per minute, cost teachers roughly 10 seconds out of every minute of classroom time. Everybody stops talking because the noise drowns out anything they say.

"You have to time the ringing of the bell," she says one summer morning. "If you ring it when an airplane goes over, nobody hears it." The whirlwind-like vortex from a passing airplane shattered tiles on the roof of the school's kitchen. Sometimes vortices suck the shingles off roofs like a vacuum. Heathrow confirmed 102 "vortex strikes" on nearby buildings in the last fiscal year. Whenever this happens, the airport sends workers out to the damaged properties to fasten each shingle down with metal clips.

While airplanes have grown quieter, the number of flights to and from Heathrow has nearly doubled in the last 25 years—like a shift, locals say, from an occasional truck passing your window to constant traffic.

Noise is loud enough to irritate at least 300,000 people, the government says. Studies in nearby neighborhoods have found the noise impairs schoolchildren's reading comprehension and memory. In 2001 the European Court of Human Rights ruled that the rights of the airport's neighbors to peaceful sleep had been violated. The ruling was later reversed, but the airport now offers neighbors up to about $24,000—depending on the value of their home—to move away.

Tension over airport noise, mounting for decades, has brought Heathrow under some of the tightest noise restrictions in the world. Pilots descend toward the airport on a smooth trajectory, rather than dropping in stair steps from one level altitude to the next. In the continuous-descent approach, as it's known, pilots do not gun the engines to level off along the way, and airplanes remain farther above homes—cutting noise roughly in half. Unlike many U.S. airports, Heathrow is privately owned, and its noise strategies are distinctly free-market. The louder an airplane, the higher its landing fees.

Computers linked to air traffic control radar track each airplane, and pilots who do not follow the rules get a talking-to from airport managers. Microphones at the end of runways track noise, and each airplane that breaks the limits gets fined up to $2,000.

Rules tighten at night, when the noisiest aircraft are banned entirely: Only about 16 airplanes are permitted to land or take off between 11:30 p.m. and 6 a.m., and the noisier they are, the fewer are allowed. Sometimes early airplanes circle in the sky until the curfew lifts.

Manufacturers design airplanes with Heathrow in mind. Airbus worked over the engines and wings of its double-deck A380 to make sure it would meet Heathrow's noise rules. Boeing guar-

ABOVE: MARK WAGNER/AVIATION IMAGES.COM

antees its new 747-800 will fly quietly enough to be allowed in and out of Heathrow at night.

Airliners at Heathrow take off from only one runway while landing on the other, lending a semblance of order to the place. At 3 p.m. each day, they switch—landing on the one they took off from in the morning. It takes air traffic controllers about a half-hour to orchestrate the switch. With some exceptions, depending on the prevailing winds, it gives people living at each end of the runway half a day of relative peace and quiet.

Airport managers and airlines also want to start landing and taking off on both runways at the same time, which would let controllers put airplanes closer together and squeeze more in. They also want that third runway.

Current runway limits push airlines toward more profitable big airplanes that fly greater distances, leaving less runway space for shorter connecting flights. The solution, they say, is a new runway for the smaller airplanes that fly short routes, freeing the main runways for big ones. But that fix means the airport would reach beyond the façade of airport hotels and rental-car lots that surround it to take over towns to the north where "No third runway" signs outnumber flags supporting Britain's World Cup soccer team.

The British government says the third runway will go forward only if the airplanes get quieter and cleaner—the air around Heathrow now violates European Union air standards—but the mayor of London and city councils around the airport still oppose the expansion. They're urged on by a coalition of mothers worried their children's schools will get wiped out and environmentalists who blame air travel for contributing to greenhouse gases in the atmosphere.

The runway would take out about 700 homes and other buildings.

"We've lived with the airport," says Linda McCutcheon. The new runway would replace her home, as well as the house she grew up in, the church she got married in, and the schools her children attended. "We don't want the airport to go away. We just don't want it to get bigger. There will just be that many more airplanes. Where will they all go?"

Just Passing Through

Passengers at Heathrow enter an outdated and overtaxed world of parking garages turned into terminals, with ceilings so low that tall people hit their heads, moving walkways that suddenly stop moving, and blue plastic buckets on the floors of busy corridors to catch water dripping from the ceiling. Frank Bowron, a one-time Heathrow employee who travels frequently through the airport, has seen escalators feed so many people into the confines of an international connecting lobby that children had to be passed overhead to keep them out of the crush. Conditions like this would discourage even the most seasonsed travelers, which is why airport managers have a plan.

The future of Heathrow rises on the west end of the airport: a fifth terminal, built atop what used to be a sewage works, with more glass than a cathedral and the space of nearly 10 football fields on each of its five floors. The project includes a new control tower 285 feet high, more than twice as high as the old one. It's the biggest construction project in Europe, and opens in 2008 with 60 new gates—a quarter of them big enough for the A380. It will ease crowding until about 2011—when the airport is expected to again max out.

Moonbound

WHO *ISN'T* PLANNING A LUNAR MISSION THESE DAYS?

BY TONY REICHHARDT

For some, it will be a first. For others, a return. Either way, the moon is the most popular destination for robotic explorers in 2007 and 2008, as four countries – the United States, China, India, and Japan – prepare to launch spacecraft into lunar orbit.

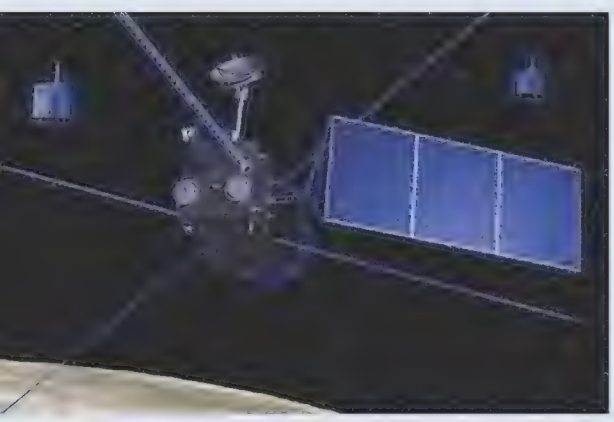
Why the moon? For one thing it's close, which makes it an ideal technological proving ground for nations taking their initial steps beyond Earth orbit, like China and India. Another reason is that planetary scientists know surprisingly little about lunar geography, gravity, and geology. Though more than 60 spacecraft have been sent there since the Soviet Luna 1 in 1959, the moon is less well mapped than you might think. The state-of-the-art cameras, spectrometers, and other instruments on the new orbiters should quickly bring lunar scholars up to speed. "When data from the four new lunar missions are returned, we will be approaching the capabilities that we currently have for Mars," says Brown University planetary scientist Carle Pieters, whose Moon Mineralogy Mapper will fly on India's Chandrayaan-1.

Herewith our quick guide to the upcoming lunar derby.

SELENE

Country: Japan
Launch: Summer 2007
In a Nutshell: With 14 instruments, this may be the most scientifically comprehensive of the new moon missions.

Japan has been to the moon before, with a small satellite called Hiten in the early 1990s. But not like this. SELENE (SELenological and ENgineering Explorer) is another leap forward for a country that has been rapidly expanding its capabilities in solar system exploration with projects like the 2005 Hayabusa asteroid rendezvous. Bernard Foing, a lunar scientist with the European Space Agency, calls SELENE, with its impressive 660 pounds of instruments, "the Lexus of lunar exploration." Scientifically, it does a bit of everything, and some things none of the rest will do, including deploying two small subsatellites to measure the gravity field on the far side of the moon—important data for fine-tuning spacecraft orbits. A radar sounder will probe deep below the surface, and a high-definition camera will return photos of Earthrise and lunar craters for the public to enjoy.



JAXA

The three-ton SELENE will need Japan's HII-A heavy launcher.

CHANG'E-1

Country: China
Launch: Fall 2007
In a Nutshell: This modest orbiter is the first of several lunar missions China has planned, and may be the precursor to human landings.

Chinese scientists have outlined three phases for their lunar exploration program, starting with an orbiter this year and progressing to a lander in 2012 and sample return mission in 2017. Chang'E-1 (named for a Chinese legend about a young fairy who flies to the moon) will take stereo pictures of the surface and investigate solar radiation and charged particles around the moon. Lunar resources are a special focus: Onboard spectrometers will map the abundance of metals and helium-3, a potential fuel source for future fusion reactors. A microwave radiometer—the only one on any of these four missions—will measure the thickness of the lunar soil. That's the kind of information you'd need if you were planning a lunar base, which, according to some Chinese scientists, is the long-term plan for that country.

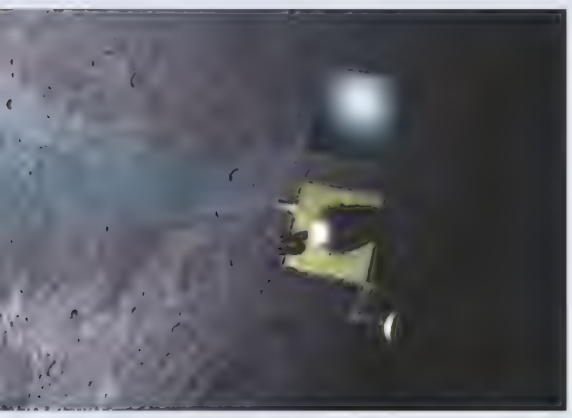
Chang'E-1's 120-mile orbit is the highest of all the missions.

OPPOSITE: CAST; ABOVE: NASA

CHANDRAYAAN-1

Country: India, with European and U.S. participation
Launch: Spring 2008
In a Nutshell: India's first venture beyond Earth orbit gets this technology-savvy nation into the game of deep-space exploration.

India is building the spacecraft and furnishing the launcher, although it invited international scientists to join in proposing instruments. Among the foreign contributions are a German-built infrared spectrometer modeled after one that flew on Europe's recently ended SMART-1 lunar mission, and the NASA-supplied Moon Mineralogy Mapper, which has an even higher resolution. Between them, they will do a thorough job of mapping rock types on the lunar surface. India excels at Earth observation from space, and its homegrown Terrain Mapping Camera will return high-resolution stereo pictures that can be converted into digital terrain maps. Another U.S. instrument, called Mini-SAR, similar to the synthetic aperture radars used to explore Earth and Venus, will search for signs of water ice at the poles.



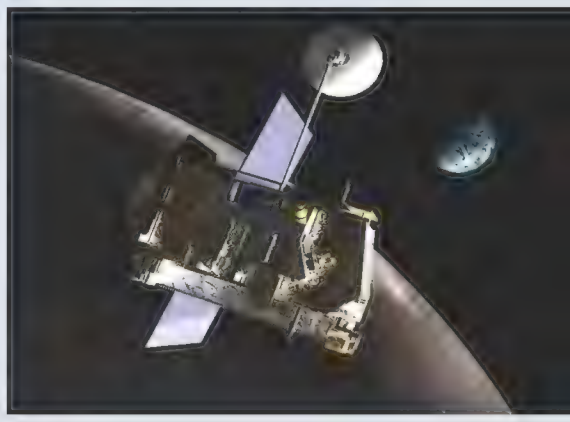
ISRO

Chandrayaan-1 carries a small probe to hit the moon's surface.

LUNAR RECONNAISSANCE ORBITER

Country: United States
Launch: Fall 2008
In a Nutshell: NASA wants better maps of the lunar surface before astronauts arrive in 2020, and LRO will discern details only a foot or two across.

The LRO's main purpose is to pave the way for future human explorers, and that preparation includes taking extremely high-resolution images of potential landing sites. To do that, the spacecraft will orbit much closer than any of the others—only 31 miles above the surface. Details less than three feet should show up in the images, meaning that 40 years after the Apollo astronauts walked on the moon, we'll once again see pictures of their equipment and vehicles dotting the lunar landscape. LRO will use a laser-ranger to measure landscape elevations, and will train its instruments on the lunar poles, looking for water and other potentially useful resources. Helping in the search for water is an add-on experiment called LCROSS: An upper-rocket stage will be sent crashing to the surface and scientists will study what flies up from the impact.



NASA

LRO, with six scientific instruments, will orbit the moon for one year.

EXTREME AIRSHOW

A FELLOW PERFORMER REMEMBERS THE ACT THAT PUSHED TOO FAR.

BY DEBBIE GARY

IN 37 YEARS OF FLYING AEROBATICS, I have come to think of airshows as a great place to hang out with my friends. Much of the flying has been a backdrop for parties and picnics, but every once in a while, I have been grabbed and held in a time-stopping moment as I watched someone fly. When it has happened, I recall the color of the air, the shirt on the back of the man in front of me, the gasps and sighs of the audience, and the airplane filling the sky: A Vulcan bomber with its wing nearly scraping the ground in a turn. Bob Hoover's Aero Commander looping and rolling with both engines off. Jim Holland's green and white Citabria doing a low-level outside loop. A Red Baron Stearman flying a simple early morning show in air so thick and still that the plane's smoke trailed behind it like white crepe paper in a blue room.

But the greatest time-stopper was the Masters of Disaster, an act with three pilots—Jimmy Franklin, Bobby Younkin, and Jim LeRoy—who tore up the sky, chased each other, raced jet trucks, dodged fire and smoke, and changed what we expected from airshows forever. It was an act that scared us silly, made us wish they would never stop, then broke our hearts when two of them, Franklin and Younkin, were killed flying at an airshow in Moose Jaw, Saskatchewan, on July 10, 2005.

The last time I saw them was the year before, at the Experimental Aircraft Association fly-in at Oshkosh, Wisconsin. Before they flew, Kyle Franklin, Jimmy's son, warned the audience: "This is dangerous. This is a high-risk act." Then, instead of announcing the act and reciting the usual statistics and how-great-I-am bios, he turned on the soundtrack and narrative tape.

It began with epic science fiction movie music, and a robotic voice that said: "Ladies and gentlemen, children of all ages, allow me to take you back—far, far back to the gloomy dark ages of the early 15th century, a time when jet-powered vehicles roamed the face of the earth, unregulated, unmerciful, and undeterred, opposed only by the Fully Automated Annihilators, known to all as the FAA." Here hyenas laughed like maniacs.

Before any airplane took off, a wall of people, a mile long, was up against the crowd line; they were all holding their breath. I was in the performers' pit, and every pilot was standing as close as he or she could get to the flightline. At one end of the runway, LeRoy was in the black and yellow Pitts with a modified 400-horsepower Lycoming engine (his "Bulldog Pitts," he called it), and at the opposite end, Younkin was in *Samson*, a 450-hp black and red replica, built by Steve and Liz Wolf, of a 1940s racing biplane. At crowd center, on a parallel taxiway, Franklin's massive black Waco grumbled and hissed smoke, its uncowled General Electric J85 jet engine clamped to its belly like a demon hitching a ride.

While the pilots worked the crowd, revving their engines and blasting smoke behind their planes, the music and nar-

The Masters of Disaster ratcheted up the drama with a jet-powered Waco UPF-7 biplane and a Chevy truck.

BILL VAN PELT

ration weaved a tongue-in-cheek spell, recalling an over-the-top B-movie: *King Kong Meets Godzilla With Howling Biplanes, Jet Trucks, and a Wall of Flame.* This was going to be an in-your-face show, one that defied convention and mocked what the pilots would call "the misplaced desire to dumb down a genuinely dangerous profession."

The soundtrack shifted from science fiction to a horror movie funeral march. Then a wolf howled, dogs barked, and an air raid siren wailed above the airfield. From opposite ends of the runway, two biplanes raced toward each other. LeRoy yanked his Pitts off the runway and straight into a vertical climb, stopped it mid-air, then hovered just above the runway. Younkin, meanwhile, aimed for the Pitts, snap-rolling *Samson* just above it.

Younkin, who always made crowds gasp with his low-level snap-rolls on takeoff, had taught himself aerobatics when he was 16. He was in the back seat of his father's new Decathlon while Jim, his father, practiced slow rolls. Like all beginners, Jim was having a hard time with them. Every time the plane rolled to the left, its nose dropped sharply and veered to the right at the end. When Bobby pointed that out, Jim said: "Well you try it!" Bobby did, and just from analyzing his father's attempts he did it exactly right. Today, Jim recalls thinking, *Maybe aerobatics is like music; those who are going to excel have this special gift.* "Gifted people are very intense and they are the ones who want to practice all the time," he says. "Bobby had to be flying all the time."

Younkin flew his first airshow when he was 18, but made his living hauling freight in a Twin Beech and a Learjet. Later, he performed at airshows in both aircraft. Neither had been designed for aerobatic flying, but he flew them within their allowable G-load limits, with precision and grace.

The Masters of Disaster fed another side of Younkin's personality. "On one hand, Bobby was this kind, gentle, polite Southern gentleman," LeRoy says, "but when he strapped into *Samson* the horns came out—the devil horns!" The act brought out the horns in all of them.

Above the Oshkosh runway, after dazzling solo maneuvers, Younkin and LeRoy chased each other to 500 feet, where they drew a smoky circle. Franklin lit the fire in his big black 2,000-horsepower Waco. With a 50-foot, 1.5-second ground roll, the plane leaped into the air and rocketed through the circle like a bullet through a bull's eye. As the team's pyro experts set off the first charge of dynamite on the far side of the runway, guitars and drums exploded into a heavy metal frenzy.

When I first flew at shows Franklin performed in, back in the early 1970s, he was notorious for consistent but daring low-level flying. Someone asked him, "Why do you fly

EAA

Jimmy Franklin debuted his J85-powered Waco in 1999. Before MOD, he flew the one-of-a-kind aircraft for numerous wing-walkers, including his son Kyle (left), now part of a MOD spinoff act called Sons of Legends.

so low? Half the people can't see you." He answered, "Yeah, but they're trying."

Most pilots have to work their way down to extremely low altitudes, but Franklin grew up in a flying family in New Mexico, where he and his brother Steve would fly between the family's two ranches. "We never got above power-line height," Steve says, "and sometimes we would go under them." They routinely rolled their Super Cub tires along the ground for entertainment, and once, when they were out without a shotgun, they tried to bop a coyote on the head with the tail wheel.

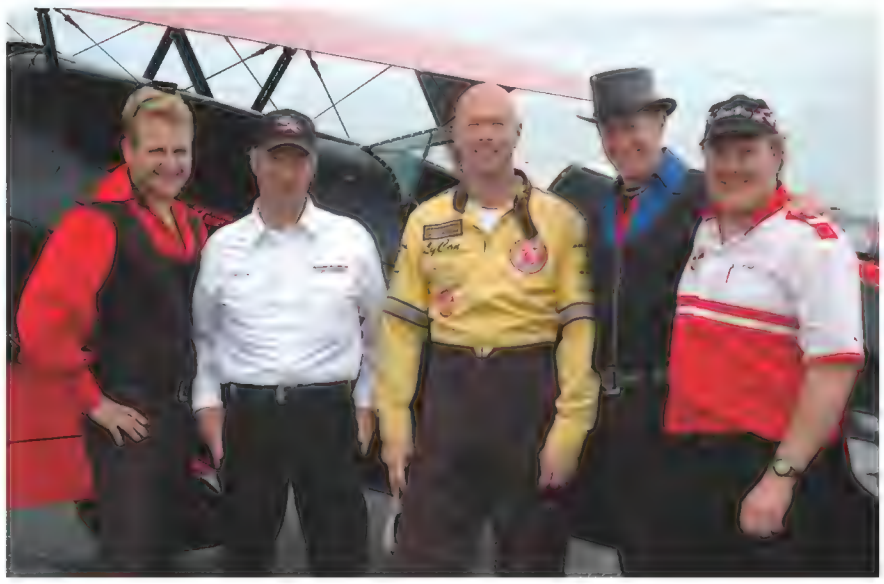
The low-level flying could backfire. Once, in the 1980s, Franklin made a low turn during a solo routine in an Aerostar and sliced off a bit of wingtip on a fence he had not seen (he landed without a problem, and parked his aircraft so the wingtip wasn't visible). But anyone who saw his inverted pickup of a ribbon suspended between two Coke bottles would probably agree that the low flying paid off.

Franklin's plane was as wild as his imagination. He got the idea of adding a jet engine to the Waco when he saw *Star Wars*, but he couldn't find a builder willing to figure out how to do it. Then, in the 1990s, he met Les Shockley, who made a business out of putting jet engines on trucks. Shockley figured out how to put one safely on the modified Waco. At Oshkosh, after Franklin torque-rolled above the airfield, he yanked the jet around to join the other airplanes, already fighting like yard dogs with their teeth bared. On the ground, the pyrotechnics team, headed by Rich and Dee Gibson, watched for opportunities. Any time the airplanes flew low over the pyro field, the team exploded dynamite in cardboard boxes filled with plastic bags of gasoline. "Everyone expects the fire, smoke, and noise," Rich Gibson says, "but they're all surprised by the heat." At the end of the show, when they lit a thousand-foot wall of fire, we could feel it on the other side of the runway.

Gibson was an explosives expert in Vietnam, where he disarmed booby traps for the Army. In 1981 he helped the (then-named) Confederate Air Force simulate bombs and strafing runs at an airshow in Rockford, Illinois, and warbird pilots have been demanding the talents of Rich's Incredible Pyro ever since. "MOD was the first time that we used pyro strictly to add to the entertainment value," he says. It may not have made technical sense in the dogfight, but the Masters of Disasters was not about logic.

"I've never been a fan of the typical airshow dogfight," LeRoy says. "The pilots might be having fun as they try to get each other in their gunsights, but it can lack entertainment value. With the MOD dogfight, we took the most crowd-pleasing aspects—near-misses and close chases—and did them over and over, while never getting too far from show center."

Like the other two pilots, LeRoy grew up in a flying family: His father, uncle, and grandfather were airline pilots. He took his first aerobatic lesson at Art Scholl Aviation in 1984 while serving in the Marine Corps at Camp Pendleton in California. By 1992 LeRoy had saved enough money



SCOTT SLOCUM

ADAM DOMBOWSKY

Above, left to right: Kyle Franklin; MOD pilots Bobby Younkin, Jim LeRoy, and Jimmy Franklin; and Kent Shockley, MOD's jet truck driver. After Younkin's and Franklin's airplanes collided at a 2005 Moose Jaw airshow (left; LeRoy's Bulldog Pitts is below), Canadian investigators concluded that recent modifications to the act had made it more vulnerable to collision.

LeRoy, Franklin, and Younkin (left to right) and the act's Peterbilt truck in a moment of high-energy symmetry.

to buy his first aircraft, a 1979 Super Decathlon. He performed in his first airshow in 1995.

LeRoy and Franklin first flew together in 2001 at the Elkhart, Indiana airshow; the organizers put them in the air at the same time for a competitive flyoff. They liked each other's style, so three months later they began practicing aggressive dogfighting. In 2002 they flew shows together as an act, adding pyro and the two-airplane jet truck attack. The following year, Younkin, who had flown many airshow dogfights with Franklin, joined up (officially, the members of the act were the X Team, and the act itself was the Masters of Disaster).

MOD did not emphasize aerobatic maneuvers, says LeRoy, but rather near-misses and lots of things happening simultaneously, like explosions and flying though the flames produced by the jet truck. MOD was fluid. LeRoy compares it to the Jimi Hendrix song "Little Wing": "There was a beginning, middle, and end, with lyrics that were sung basically the same every time," he says, "but in between this structure were wonderful variations, and every live performance was different."

To transition from the dogfight to the jet truck attack, the pilots did a maneuver with turns, splits, and close crosses that they called the Dairy Turn. At the end of it, the three would be coming at the truck from different directions.

While they did that, Kent Shockley, Les' son, fired up *Shockwave*. Built on a 359 Peterbilt shell, the truck has three Pratt & Whitney J34-48 afterburning engines that produce a total of 36,000 pounds of thrust. After a 300-mph dash down the runway, the truck relies on six wheel disc brakes and two 16-foot parachutes to stop. "Nothing on it has been chopped down," Shockley says. "It is as aerodynamic as a barn."

As it drove down the taxiway, the truck spewed a dragon's breath of flames and clouds of smoke thick enough to hide a battleship. On the soundtrack Kid Rock sang, "I am the bullgod, I am free...," followed by a 1950s oldie, "Beep, beep, beep, beep, his horn went beep, beep, beep...," and back to Kid Rock: "I'm tripping, tripping...," then a double clutch into "Whoa black betty, bam-a-lam...."

The planes popped in and out of the smoke, diving on the truck until it reached the end of the taxiway, where it turned onto the runway for the grand finale: the airplane race, with the thousand-foot wall of fire as a backdrop. Shockley describes the view from inside the truck: "They

Against the MOD wall-of-fire backdrop, Younkin shows off *Samson*, his replica of a 1940s Curtiss Pitts-designed racer.

LEFT: BEN LANTERMAN; ABOVE: SCOTT SLOCUM

VIA KYLE FRANKLIN

Franklin races the *Shockwave* truck, while LeRoy tears off in the opposite direction. "Near-misses and close chases" were MOD's trademarks, says LeRoy.

tried to time it so they were slicing by the truck at the same time. When they were getting close, I torched them. If they were coming in on the right side, they would bank left and slice right through the flame.

"You've seen a lot of these acts where guys fly by each other, looking like they are going to hit each other, but they leave a small margin for error. But those guys flew as close as it looked.

"Probably the most exciting thing was the head-to-head. Franklin would be coming up from behind, Bobby would be overhead, and LeRoy would come out of a hover 5,000 feet from the vehicle when he flattened out on the runway. That was my cue to launch. I would travel 2,000 feet, which is how long it takes for the truck to reach 300 mph. LeRoy would be off the edge of the runway, coming at me trimming the grass with his wheel pants. We crossed at a 500-mph closure rate."

As a spectator, I thought the scariest part of the show was when the planes disappeared in the smoke. But in the end, when Franklin and Younkin collided, it was in clear air.

It was Sunday, July 10, 2005, at the Saskatchewan Airshow in Moose Jaw, home of the Canadian Armed Forces jet demonstration team, the Snowbirds. MOD was the last act to fly before the Snowbirds. "The first part of our demonstration had gone flawlessly," LeRoy recalls. "We were nailing our crosses and flying a fairly tight show.

"And then they were gone. It happened just that fast."

According to the findings of the Transportation Safety Board of Canada's accident investigation board:

"The Dairy Turn manoeuvre had been modified such that a temporary loss of visual contact could occur immediately before the aircraft crossed flight paths. This modification made timing critical and added two potential points of collision....

"The climb initiated and maintained by the Wolf-*Samson* pilot was not part of the planned manoeuvre. The climb was consistent with the pilot concluding that the Waco was late, and because he did not have visual contact with the Waco, that there was an imminent risk of collision. His climb would have permitted the Waco to pass ahead and below.

"The climb of the Waco pilot was consistent with the pilot concluding that the lateness of the turn toward the Wolf-*Samson* had created an imminent risk of collision if the manoeuvre was continued as scripted. His turn to the left is consistent with an attempt to fly away from the potential collision. The actions of each performer negated the actions of the other.

"The Waco and the Wolf-*Samson* collided near show centre at about the 1500-foot show line. Both biplanes caught fire and crashed between the 1500-foot show line and the outer runway. Both pilots were killed at impact, and both aircraft were destroyed. All debris fell away from the crowd toward the outer runway."

IN TALKING ABOUT THE ACCIDENT, the Younkin and Franklin kids are careful not to speculate about what any of the pilots did that might have led to the accident. However, Kyle does say, "Even if you had told Bobby and my dad that they were going to die doing that act... Well, everybody did...but they continued doing it anyway, because they had so much fun."

Since the accident, Matt Younkin, Bobby's son, has learned aerobatics. His sister Amanda, who also is a pilot, says, "My dad wanted us to learn aerobatics because it is in our blood, but he did not want us to go into airshows. Matt didn't even consider it until the accident happened, and the main reason he is doing it is because he is having so much fun, and he wants to keep my dad's name out there. After accidents happen to people like the French Connection [airshow pilots Daniel Heligoin and Montaine Mallet] and Charlie Hillard, you never hear about them anymore. They were

Since the accident, LeRoy has put together a number of MOD spinoffs. In an aggressive act called Tinstix of Dynamite (right), MOD's Rich Gibson stages the pyrotechnics.

legends, you know? We don't want that to happen."

Amanda, who married Kyle Franklin last October, books Kyle and Matt at shows under the name Sons of Legends. It is a barnstorming act, with a wing-dragging comedy routine, a motorcycle-to-airplane transfer, and good old-fashioned airshow flying, the kind their dads did at the beginning of their own airshow careers. The Sons are not trying to fly like Masters of Disaster, but they have experimented with dogfighting and formation flying. Kyle defends his father's brand of airshowmanship: "People in the airshow industry want everything to be so safe," he says. "Safe is fine, but you don't tell the crowd how safe it is. They are not coming here to watch, 'Oh, look at this guy fly safe.' They want to be thrilled. They want the aspect of danger."

LeRoy has created an act called Tinstix of Dynamite. The show includes pyro expert Rich Gibson and world aerobatic competition pilot Jurgis Kairys of Lithuania. For the 2007 season, LeRoy is adding another pilot: Skip Stewart (see "So You Want to Be an Airshow Pilot," Apr./May 2005). Unlike MOD, this act is completely choreographed, but there is no lack of fire, explosions, and other theatrics. The grand finale is an "opposing double inverted ribbon cut"—two aircraft cutting two ribbons while flying inverted in opposite directions.

STEVE SCHULTE

In 2007, the remaining MOD team mates will bring back a new version of the show, with Skip Stewart flying opposite LeRoy. "Three of the five members are still here," says LeRoy, "and we feel that the best way to honor the memory of Jimmy and Bobby is to continue." The Franklins and Younkins object to the group using the name of the act in which their fathers were killed. "When the time is right, we will retire the name in their honor," says LeRoy, "but we've got some work to do first. I don't want this business to ever forget that name."

STEVE SCHULTE

In Tinstix, world aerobatics champion Jurgis Kairys flies a Sukhoi Su 31 with a 400-hp Vedeneyev M14 engine; LeRoy continues to fly his Bulldog Pitts. LeRoy has also flown a Tribute to the Masters act, which will be superseded by a new version of the Masters of Disaster, scheduled to debut in 2007.

The first time I saw MOD was in 2002, and we were all flying a week-long show at a motorcycle rally in Sturgis, South Dakota. The act did not yet have its name, Younkin, or the wild soundtrack. Men and motorcycles lined the fence. When LeRoy jumped the jet truck from head-on, the crowd gasped, I laughed, and the man next to me fell off his Harley.

The last time I saw them, in Oshkosh, I stood next to Joe Schumacher, the airshow's director of aircraft operations, who was grinning broadly at their antics. While the biplanes chased each other like ravenous wolves and the pyro field erupted like a chain of volcanoes, I turned to Schumacher and said, "Every time I watch them I have the same reaction. I pray that they will be safe and I wish I were in my airplane with them."

THE THIN ALUMINUM LINE

SUPERSONIC AIRPLANES AND A SCREEN OF RADAR STOOD READY DURING THE COLD WAR TO AVERT THE END OF THE WORLD. BY CARL POSEY

IN THE 1950S, EVERYONE knew how the Third World War would be fought. Hundreds of Soviet bombers would sweep south across the Arctic, hauling thermonuclear loads destined for U.S. cities. The response, too, was a given. Fighters would rise to meet the intruders as they crossed into North American airspace, taking down as many bombers as possible. As the battle moved south, anti-aircraft missiles would also rise to knock out the bombers.

Some enemies would get through. Air defense, in the view of those within the newly created Strategic Air Command, was like boxing. You took a few punches, then knocked the other guy out with your own city-incinerating bombers.

To prevent this exchange, Pentagon strategists concentrated on building offensive weapons that would guarantee delivery of massive strikes. So, at the expense of fighters, SAC developed increasingly capable strategic bombers. In the early 1950s the only aircraft waiting to counter the Soviet long-range bomber fleets were the aging workhorse aircraft of the Korean War. The United States stationed a contingent of these aircraft at forward-deployed bases in Alaska.

The Lockheed F-94As and F-82 Twin Mustangs standing alert at these bases were hardly equipped for the task. "A [Soviet] Il-28 Beagle coming over, we were supposed to intercept him and force him to land by aiming a .45 pistol at him," jokes Guy Sherrill, a retired Air Force colonel who flew F-94s from Galena and King Salmon airbases in 1953.

Sherrill had been chosen to train on a new all-weather jet interceptor, Northrop Grumman's F-89, a big, straight-wing, twin-engine two-seater. Someone discerned a stinger in the high T-tail and dubbed the low-slung machine "Scorpion."

The F-89 had first flown in August 1948, but even in the early years of production had acquired a bad reputation. At the time Sherrill was supposed to train on them, the Scorpions were grounded, he says, "because their wings were falling off." Instead, he got interceptor training in a B-25 and went on to fly the F-94. Later, he would stand his fair share of Arctic alerts with the Scorpion's improved J version, whose wings stayed on in flight.

Scorpions entered service in 1950, but by then they were already antiquated. "The bombers were ahead of us," Sherrill says, citing training attempts to intercept a B-52 at 46,000 feet. "Only way to do it was straight up. [You] finally got a firing position, then started sliding backwards."

Fast new bombers were also appearing on the Soviet side. The Tupolev Tu-16 Badger was seen in 1953, and the Tu-95 Bear, a swept-wing turboprop giant, a year later. No mere knockoffs of Western designs, they were as different from their U.S. counterparts as Klingon Birds of Prey are from Federation Starships. "We had the -89J for a couple of years," recalls Alex McDonald, who ended his North Dakota Air National Guard career as a major general. "Despite being slow and heavy, we were very successful in our intercepts against B-58s and that sort of airplane. But we couldn't chase them down."

To compensate, the F-89J was armed with MB-1 Genies, an unguided nuclear missile that could be fired at enemy bombers (See "Suicide by Genie?", p. 33).

The inability to catch fast bombers was proof to some within the Air Force that the interceptor fleet needed to be upgraded, as part of a larger overhaul. What was required to deflect a Soviet attack was not

COURTESY ELMENDORF AFB OFFICE OF HISTORY

The sole purpose of F-102s, here over Alaska's Elmendorf Air Force Base, was to scare off bombers.

The Soviets' first atomic bomb test in 1949, in background, prompted tense aerial duels between (top to bottom) Soviet Tu-95 bombers, F-101s, and F-102s. Bottom: The blast effects of a one megaton bomb exploding over Pittsburgh.

a clutch of obsolescent aircraft guided by World War II-vintage radars but an impenetrable defensive umbrella. A new system to detect intruders was needed, and new airplanes to chase them down and kill them.

TO EXPLORE WAYS to make North American nuclear defense less porous, the Massachusetts Institute of Technology in 1952 convened a Summer Study Group. It started with the idea of creating a radar net around the northern fringe of North America.

The system the scientists created became a massive joint undertaking by the United States and Canada and relied on groundbreaking computer technology to manage information. To develop it, MIT created an air defense lab that later morphed into the Lincoln Laboratory, which remains famous for research in missile defense, space surveillance, and civilian air traffic control. The brains of the information management system would be called the Semi-Automatic Ground Environment, or SAGE.

Centrally located digital computers would monitor data from a picket line of new-generation radars, then vector interceptors toward targets. Surface-to-air missiles, as well as interceptors from southern U.S. bases, would also engage the Soviet bombers as the battle spread south. The MIT group estimated that such a system could exterminate 60 or 70 percent of the attackers.

Offense-minded officials in the Air Force were not impressed. Although the Battle of Britain in World War II had demonstrated that contemporary interceptors guided by ground radar were more effective than fighters patrolling on their own, pilots preferred keeping command and control in the cockpit.

Critics in the Air Force and elsewhere likened the idea to the Maginot Line, whose redoubts had been deftly flanked by the German blitzkrieg, and derided MIT proponents as "Maginot boys."

There was, however, a crucial difference. While France was defending against old threats, the proposed defensive system aimed to counter entirely new kinds of threats with the freshest technology. The system employed computer, radar, and aircraft designs that were then just gleams in the eyes of programmers, scientists, and engineers.

The project advanced in spite of its detractors. In 1957, the first SAGE control center was dedicated at McGuire Air Force Base in New Jersey; within four years 22 more centers were operating. SAGE monitored the airspace over Canada and all of the United States except Alaska. (Interceptors in Alaska received radar information relayed to them by North American Aerospace Defense Command.)

SAGE's four-story, windowless blockhouses were not much to look at from the outside. Within the six-foot-thick concrete walls, however, were some of the world's most advanced computers and communications gear. A 300-ton FSQ-7 computer filled the second floor, its 70 cabinets housing 58,000 humming vac-

COLLAGE: DAVID PETERS; SOURCES: NASM (SI NEG. #85-16420); NASM (SI NEG. #IB44791); SOVFOTO

uum tubes. The facilities had no heating; in winter, the vacuum tubes kept them warm.

On another floor, Air Force personnel sat in the soft blue light of communications and display consoles, watching for signs of war.

New radar picket lines were going up in the north. Begun in 1951, the Pinetree Radar Line by 1954 had 30 manned stations along the U.S.-Canada border at 49 degrees north latitude. A Mid-Canada Line, built in the late 1950s, provided a fence of eight main and 90 unmanned Doppler stations along the 55th parallel.

The most daunting feat, however, was raising the northernmost radar fence: the Distant Early Warning (DEW) Line, draped along the 70th parallel from western Alaska and the Aleutian chain eastward across Canada to Greenland. When President Dwight Eisenhower approved construction in February 1954, virtually the only structures north of the continent's tree line were Inuit villages.

Just three years later, 58 stations were operational; the number would eventually grow to 70. Each main station had big AN/FPS-19 L-band search radar (or, in the two Greenland stations, a more powerful AN/FPS-20). Unattended AN/FPS-124 Doppler radars filled in the gaps, looking for low-flying targets.

Perched precariously atop rocky promontories or along the pebbly, ice-bound shores of the Arctic seas, most DEW Line stations existed in almost total isolation, broken only by occasional airlifts of people and supplies.

The missing piece of this new air defense scheme was an all-weather fighter that could catch anything the other side deployed.

WHEN THE AIR FORCE started what it called the "Ultimate Interceptor Program," it began by looking at a design that had been shelved years before.

In September 1948, just weeks after the F-89's maiden flight, the Consolidated Vultee XF-92 had made its first flight, at Edwards Air Force Base in California. Clean and arrow-like, it was the first military jet to incorporate the delta wing, pioneered by German designer Alexander Lippisch. At the time, however, airplanes built for long-range escort and penetration missions were eclipsing interceptors, and the XF-92 program was shut down.

In 1951, the Air Force asked Convair to take another look. The result was the YF-102, similar to the earlier delta prototype but larger.

Engineers applied the then-novel area rule to sand away transonic drag, making a determinedly subsonic airplane supersonic. (Even if an airplane is flying at subsonic speed, localized areas of airflow can be supersonic, and the resulting shock waves cause considerable drag. The effect can be reduced by presenting a smaller area to the oncoming flow.)

The YF-102 first flew in October 1953 and, after considerable tweaking, went to the Air Force in 1956. The F-102 was officially named the Delta Dagger but universally called "the Deuce." Controllers monitoring radar signals from the DEW line and elsewhere were to vector the -102 into the area of a target, where its own radar could guide it to complete the attack.

In 1954, formations of F-89s flew over Anchorage, before advances in Soviet bombers necessitated their replacement.

ALTHOUGH THE DEUCE WAS INTENDED AS AN INTERIM FIX, IT DID MUCH OF THE AIR DEFENSE COMMAND'S HEAVY LIFTING IN THE NORTH.

Paranoia's infrastructure: Drab SAGE buildings (left) hid advanced computers; radar domes guide CF-100s over Canada.

COURTESY ROGER MOLA/NATIONAL ARCHIVES (2)

NASM (SI NEG. #1B28595)

The first supersonic military jet, it had a top speed of 810 mph at 35,000 feet (about Mach 1.2), a ceiling of 55,000 feet, and a thousand-mile range. Its armament comprised two dozen 2.75-inch folding-fin aircraft rockets and four Falcon AIM-4 missiles, two guided by radar and two by infrared.

"For someone just out of flight school, the Deuce was a pretty big step up," recalls Ralph Hanna, who spent much of his career in air defense. After six months of training for T-37s and an additional eight months on T-33s, the F-102s were an adjustment, and not just because they were faster, bigger, and more powerful.

"The biggest thing was trying to fly and work radar at the same time," says Hanna. "You really learned to use the radar once you got to an operational unit—under the tutelage of a senior guy."

Although the Deuce was intended as an interim fix until its successor arrived, it did much of the Air Defense Command's heavy lifting in the north. For a couple of decades, the F-102 flew from forward bases in Alaska, New England, Greenland, and Iceland. More than 1,000 F-102s would be built before production ended in 1958.

But the F-102 was not "the Ultimate Interceptor." Even admirers acknowledged that the -102 was underpowered, had a limited range, and lacked avionics that could take full advantage of SAGE technology. Air Force officials were still waiting on the ideal advanced interceptor. "When the -102 came out, there was the idea...that something better was coming," notes retired Colonel Fred Williams, who logged thousands of hours at the controls of interceptors.

SOMETHING BETTER did come—the F-102B, which first flew in the spring of 1956. Despite the B designation, it was a new airplane, and was soon renamed the F-106 Delta Dart. Those who flew it called it "the Six." It went to the Air Defense Command in mid-1959.

"The -106 did Mach 2.2," recalls Jim Geddes, who flew both Deuces and Sixes. "Several of us had it up to 2.5 Mach and above. Maximum altitude of 65,000 feet, but you could get well above that."

Ralph Hanna called its avionics "a quantum leap ahead.... The -102s were all analog. The -106 was the first airplane with a digital computer. It was a Cadillac—a great airplane from the pilot's standpoint."

The aircraft could cruise at Mach .92 with external tanks. The early models of the Six were "round eyes," with conventional instruments, but later configurations had vertical gauge tapes, which Hanna found "a neat way to fly."

The Six fit seamlessly into the SAGE

A Cold War Intruder Alarm

THE DISTANT EARLY WARNING LINE was the farthest north of three radar fences set up to detect Soviet bombers. The main stations controlled between two and four auxiliary sites. The air bases listed would be among the first to respond to an attack coming over the North Pole.

JUAN THOMASSIE

NASM (SI NEG. #1A23742-A)

Two F-106s with the 318th Fighter-Interceptor group get cozy.

system, which was designed to control the interceptor after takeoff, direct it to the target, and bring it back to a final approach to its runway, where the pilot would make the landing. SAGE had been designed to select and fire weapons, but most pilots prefer to handle that job themselves.

"All you had to do was select the armament, shoot, and return to base," says William Neville, a retired California Air National Guard brigadier general. "Never say a word to anybody. The computer locked onto the inbound target and onto you. You saw everything on the tactical situation display. The computer in the -106 determined the type of attack. For a low-altitude target, it would roll the airplane very gently and roll out, better than you could do by hand. A thing of beauty."

Like most delta-wing aircraft, the Six misbehaved in a spin, sometimes in mysterious ways. Williams recounts the tale of a Montana Air National Guard F-106: "This guy was doing an intercept and got into a spin he couldn't get out of. So he punched out. But the impetus of the seat leaving the airplane pushed the nose down, and the airplane, now unstalled and trimmed, flew on to make a soft wheels-up landing in a plowed field."

Even in a spin, one didn't punch out of the Six lightly. "The concept was we would all wear spurs connected to wires that went into the seat, so when you pulled the handles, the wires pulled in your legs," Williams says. "As you went out, the seat rotated back to become a kind of sled, and then gradually released you at about 15,000 feet. I lost two friends to these."

Neville considers himself lucky to have ejected from a Six and live to tell about it. "I got one that worked," he says. "I can't think of six people who got out of [an ejection] alive."

ON MARCH 14, 1963, two Soviet Tu-16 Badgers penetrated 30 miles into U.S. airspace over Alaska's southwestern corner. The F-102s scrambled from the forward base at King Salmon couldn't overhaul the intruders before they cleared American airspace.

After this intrusion, F-106 units began sharing alert duty with the slower F-102s. The Mach 2-plus interceptors were deployed on six-week tours in Alaska as part of Project White Shoes. The pilots stood seven-day, four-hour alerts at forward

NATIONAL ARCHIVES

Pilots on alert race to get their F-102s aloft within five minutes. Intercepts, although common, were dangerous encounters in extreme conditions, and never routine.

bases, billeted with their aircraft in three-story Air Defense Command hangars replete with mess hall, library, ready room, lounge, and a fire pole for descending to the aircraft bays. Ralph Hanna remembers passing the time with games based on the few movies the pilots watched: "like bets on the number of folks killed in Clint Eastwood westerns or watching *The Pink Panther* backwards."

THE F-101 VOODOO WAS THE GREAT SUCCESS OF THE AGE OF INTERCEPTORS. IT, NOT THE F-106, SPAWNED THE F-4 PHANTOM II.

Typically, six aircraft stood five-minute alerts, two at Galena, two at King Salmon, and two at Eielson Air Force Base, near Fairbanks. At Galena, Williams says, "we sat nuke alert with one-third at all times, 18 airplanes, two on five-minute, four on nuke-ready."

Interceptions in Alaska generally went closer to the bone than they did over the Atlantic. "There were cases where Russians would start in over the border, then, when we scrambled, they ran for home," recalls Jim Geddes. "But it was understood: We catch you over our land, you're dead. A couple of times there were missiles armed, 20 seconds to fire, before getting called off."

The Atlantic targets were usually Tu-95 Bears, flying alone or in pairs as they threaded their way through the gaps between Iceland, Greenland, and North America.

The Atlantic intercepts, flown over international waters, were never surprises since the Bears were tracked by Norwegian radar from the moment they took off from Murmansk.

"We knew they could be nasty," says Hanna, who flew Deuces there. "In foul weather they would drag you down toward the water, trying to scrape you off." Often the Bear would turn very slowly out to sea, hoping to lure the interceptors past their point of no return.

"We'd fly formation with them," says Geddes. "We had 200-mm lenses. Just got right up on the wing of an airplane and went up and down the fuselage, taking pictures."

Alex McDonald recalls the story of a Deuce suffering a compressor stall as it decelerated behind a Bear, which was flying without lights that could betray its exact location. When the Deuce pilot restarted, says McDonald, "fire came up over the canopy—pretty dramatic. Every light in the Bear came on."

While the Six served in air defense for almost 30 years, it was never exported and never saw combat. "The armament wasn't good for fighter-versus-fighter," Hanna explains. "It was a bit too specialized for the NORAD defense role. [In Vietnam] most of our engagements were offensive." The big delta wing would have made a tempting target for surface-to-air missiles, and the F-106 had no defenses against them, he adds.

But it was an airplane pilots liked. "The -106 was a manly airplane, so fast and so advanced for its time," says Bill Neville. "When it all worked, it was marvelous. It's still the fastest single-engine fighter of all time."

During the development of the F-106, Convair struggled with recurring delays. The Air Force had hedged its bet with another interceptor program.

Designers took another look backward. This time the Air Force revisited the McDonnell XF-88, a defunct candidate for

Suicide by Genie?

MANY OF THE INTERCEPTORS had the capability to launch a nuclear weapon to take out incoming bombers—setting off one nuke to prevent more from reaching their targets.

Armed with a pair of Douglas MB-1 (later AIR-2A) Genie rockets, the F-89J could clear a chunk of sky. Mounted on fuselage rails with two AIM-4C Falcon missiles, each rocket weighed more than 800 pounds and was tipped with a 1.5-kiloton fission warhead. The idea was to produce an explosion big enough to destroy the bombers and their nuclear cargo.

Only one nuclear-armed Genie was ever test-fired, from an F-89J over Yucca Flats, Nevada. Retired Air Force Colonel Guy Sherrill witnessed the event: "It was fired level to detonate at 18,000 feet mean sea level... Most observers were in trenches five miles from ground zero. We were told to keep heads down until after the obvious flash, but got a good look through sunglasses well before the shock wave arrived. It was a healthy bang, but not all that sensational."

For the pilot in the air, however, surviving the launch of these big, unguided nukes required a fine hand. Having deployed a Genie, the Scorpion had to break and present its belly to the blast in the five seconds between Genie rocket ignition and nuclear detonation. Sherrill believes the Scorpion would have escaped the lethal envelope. Others considered a combat Genie launch a form of suicide.

The F-106 carried only one Genie. "You ejected it from the airplane," explains pilot Fred Williams, who spent more than 3,000 hours in the Six. "It dropped, trailing a lanyard that, when pulled, fired the rocket, which went out at 3,000 feet per second, plus your velocity. Five seconds later it blows up." (The F-102 also used a lanyard to trigger the weapon.)

Ordinarily, firing nuclear weapons required independent enabling action by two people, but not in the single-seat F-106. "In the -106, we had one of the only instances where, during DEFCON scrambles, you lost the two-man control of nukes," Williams says.

The presence of these weapons was keenly felt during times of rising Defense Condition (DEFCON) levels, such as 1962's Cuban Missile Crisis. "DEFCON three: That's quite an experience," says Williams. "You load and lock, [and] get a .38 pistol with ammo and a cookie [the compact safe containing the authentication code] for permission to 'fire as required.' "

Chasing Bears

THE CALL HAD COME in from North Bay, location of Canadian Forces Air Defense Command. The 416 Squadron Alert Crews had been scrambled and were airborne within the five-minute criterion.

This time the climb had been "Buster," with a comfortable Mach .86 transit to Gander [air base] in Newfoundland.... From Gander, the crews would fly to a strategic orbit point, or STOP, over the sea to wait for the intruders.

The Soviet Bears had taken off from a base in northern Russia. The Soviets rarely sent their strategic weapon and cruise missile carriers. They usually sent reconnaissance Bear Deltas, which would be intercepted in turn by the Royal Norwegian Air Force, the Brits, and the U.S. Air Force fighters based in Iceland. Then the Bears would continue on to North America to complete their electronic spying mission.

The Soviet air crew would approach the Canadian Air Defense Identification Zone in the middle of the night, since they preferred to land at their Cuban destination during daylight hours. To intercept a flight of bombers in such a huge chunk of airspace required astute positioning of the STOP. Intricate figure-eight maneuvers by the Voodoos ensured at least one of their airborne intercept radars was sweeping the sky in the direction of the Bear's approach. A "tally ho" radar contact on the inbound Bears meant the navigators had to quickly compute the best attack geometry for an identification pass.

While figuring all this out, the navs would guide the Voodoos into position. This was a hands-on, not an automated, procedure; an unintended "lock" on the target by the Voodoo radar might convey the impression that the Bears were under attack. The lead Voodoo would cautiously move in between the two Bears, and Voodoo number 2 would stay well back to cover the three aircraft. Once in the [ideal identification] slot, the pilot would call for the nav to switch on a powerful spotlight fixed to the side of the Voodoo, aimed up and to the left, where the tail of the Bear should be. The pilot would make a rapid transition from instruments to visual cues, while the nav picked up his camera.

The pilot would then fly close formation on the Bear. Both Voodoo pilot and nav would note the type of antennas protruding from the belly; both would try not to take too much notice of the twin 23-mm. machine guns in the tail that followed their every move. Then out around the wing and in to inspect the weapons bay, the antennas, the radar bulges, the nose of the aircraft, and the number below the cockpit. The second Voodoo would then move in on the Number 2 Bear and repeat the procedure, while the lead Voodoo circled back to cover the activity. All of this was being orchestrated in the dark, 200 miles or more off the coast of Newfoundland and Labrador in winter. And all the time, the Bears were turning back out over the ocean.

On this night, the Bears lumbered off without incident. After the interceptors had broken off, reformed, and headed west, there had been a great outbreak of relief in the cockpits. Then the inevitable "Where in hell are we?" Soon the coast of Newfoundland began to paint on the radar scopes, and they recovered safely in Gander.

CANADIAN FORCES JOINT IMAGERY CENTRE

Small but deadly, a Canadian CF-101 Voodoo escorts a Soviet Tu-95, more than twice its length, away from North America.

JACK PARTINGTON, A RETIRED CANADIAN AIR FORCE OFFICER AND FORMER COMMANDER OF THE CANADIAN 416 AW (F) SQUADRON, CONTRIBUTED THIS ACCOUNT OF A JANUARY 21, 1981 CF-101 INTERCEPTOR SCRAMBLE. IT IS ABRIDGED FROM HIS STORY "COLD SHAFT" AND APPEARS WITH PERMISSION OF THE AUTHOR.

bomber escort and long-range penetration missions, and asked the builder to create its own Ultimate Interceptor. The result was the F-101 Voodoo.

The F-101 made its first flight in May 1954, but the airplane would undergo thousands of modifications over several years before making its debut. The vastly improved F-101B was first flown in 1957, and after a good deal of further honing, the first began service with the Air Defense Command in 1957. As Voodoo orders increased, F-106 orders declined.

The Voodoo variation on the Ultimate Interceptor theme was a big, twin-engine, comfortably supersonic (about Mach 1.7) two-seater with long legs, a Hughes MA-12 fire control system, and SAGE compatibility.

The Voodoo would become a mainstay of Canada's North American air defense. Canada had been flying the Avro CF-100 Canuck, an indigenous twin-engine jet affectionately known as the "Clunk" for the sound made by its gear retracting.

For a replacement, Canada had started its own Ultimate Interceptor program. The Avro CF-105 Arrow was a supersonic, twin-engine delta wing, armed to the teeth. It was also expensive. With no customers, the program was canceled in 1959; on a single afternoon Avro sacked 20,000 employees (see "Fallen Arrow," Apr./May 1998).

The United States sent Canada BOMARC surface-to-air missiles as an alternative. (The name is a combination of the system's creators: Boeing and the Michigan Aeronautical Research Cen-

ter.) But when the controversial defense system came to an end over cost and performance issues, the Canadian government decided a supersonic interceptor might be the answer after all. Canada quickly put the Voodoos to work chasing Soviet Bears in a mission called Cold Shaft (see "Chasing Bears," p. 34).

The newer Voodoos gave Canadian crews the option of flying infrared-guided as well as radar-guided intercepts, a huge plus should enemy aircraft jam electronic systems.

According to former backseater Lynn Wagar, the infrared AIM-4 missiles gave the airplane one last crack at an intruder after firing two nuclear-tipped Genies.

The F-101Bs restored the two-man protocol for firing Genies. "I armed the weapons," says Wagar. "The pilot had the trigger up front."

The Voodoos left Canadian service in 1985, replaced by a relative handful of CF-18 Hornets. Evolutionarily, however, it was the great success of this brief age of interceptors, for the ancestral line of the F-4 Phantom II and its successors runs back to the Voodoo, not to the F-106.

NASM (SI NEG. #01B20632-A)

All bases with air defense duty had two interceptors always at the ready. At Michigan's Sawyer AFB: A pair of F-101s.

WHERE THE F-106 HAD DELIVERED ONE NEAR-PERFECT NOTE, THE NEWER AIRCRAFT WOULD DELIVER WHOLE SYMPHONIES.

Asked whether the Six had been the Ultimate Interceptor, Fred Williams manages a rueful smile. In 1977, his squadron of updated F-106s flew against the newly acquired F-15s being tested at Luke Air Force Base in Arizona.

"We did air-to-air, and that first day we did well," he says. "But after that first day, those guys figured out how to use their radars. Once they had the picture, it was all over for us."

IT WAS ALL OVER for SAGE and the radar pickets as well. Able to engage multiple targets a hundred miles away, the new breed of interceptors—McDonnell Douglas' F-4 and F-15, General Dynamics' F-16—would also be competent dogfighters and tactical bombers. Where the F-106 had delivered one near-perfect note, the newer aircraft would deliver whole symphonies.

In the end, SAGE, the DEW Line, and the Ultimate Interceptor never had to face the attack they were built to thwart.

Once intercontinental ballistic missiles and "mutual assured destruction" began to dominate strategic thinking, the focus on these specialized interceptors ended. No one can say whether a strong air defense helped deter an attack, or whether such an attack was ever really in the cards.

But even pilots doubt SAGE could have achieved the 70 percent success rate advertised by its founding fathers. "That's probably optimum," says Williams. "You're up there in the furball of war, they're coming toward you on a one-way mission over the North Pole, sky lit up with nuclear weapons, Nikes going off...."

Many of the old DEW Line sites still stand, ghost towns of abandoned trailers and radomes. Eventually, a U.S. Air Force-funded project called "Cleansweep" will erase their toxic remains from the tundra.

A new radar picket line called the North Warning System, minimally crewed, stretches across the high latitudes.

The face of air defense has changed. The North American Air Defense Command's fabled Cheyenne Mountain hideaway has shut its bomb-proof doors. In Iceland, American interceptors—not Deuces or F-4s, but F-15 Eagles—are leaving Keflavik. The Air Force has given up Galena.

But interceptor pilots still scramble, now facing the nightmarish possibility of having to chase down a hijacked airliner. The golden age of air defense may be over, but the work continues.

NASM (SI NEG. #IA23749-A)

World war could be started at any time, so interceptors had to endure all conditions. Here, an F-106A at Langley Air Force Base in Virginia stands on alert in dense fog. "The Six" was closest to what the Air Force envisioned in 1954 as the ultimate interceptor.

Sightings

PICTURES WORTH A SECOND LOOK

IN TRYING TO FIND the inner grace of airplanes, photographer John Fleck found inspiration from an unexpected source: an aviation structures engineer who told him, "Aerodynamics defines beauty with mathematical curves."

Fleck creates black-and-white images that attempt to discover something unique in the curves of each aircraft. He uses all types of cameras, from a point-and-shoot to a state-of-the-art digital SLR, to capture that distinctness. "I'm trying to find that signature photograph every airplane possesses," says Fleck. "And you don't necessarily get that photograph by flying around. I think airplanes are just as beautiful sitting on the ground as they are in the air."

His work is a little bit lonely, quiet, and slightly anticipatory. His photographs make the viewer aware that an airplane on the ground is always waiting to fly. The Grumman Bearcat that Fleck photographed in a hangar in Indianapolis (above) seems about to come to life. He used Photoshop to sharpen and clean up the image—the use of the bright white background is a technique he relies on to center the viewer's attention on the subject.

The decaying airframe of an FG-1D Corsair (opposite), a version of the Navy F4U fighter built by Goodyear, shows an airplane bruised by years of flying. The photograph doesn't tell the viewer the aircraft is in fact being restored. "I want people to understand the design and life cycles of aircraft," Fleck says.

In August, Fleck was traveling through Louisiana on his way home after an assignment and stopped by a small airport in Monroe. There, he persuaded the airport owner to pull his Ercoupe out for a portrait (opposite, top). "These planes have personalities," he says. "Some are comical and some are serious."

The Beauty of Kennedy

A new book documents the grand history that has unfolded at the nation's spaceport.

In 1961, technicians at Cape Canaveral prepared a Mercury Redstone for launch, filling the lower tank with kerosene and the upper with liquid oxygen.

NASA/61-4457

Kennedy Space Center: Gateway to Space

by David West Reynolds. Firefly Books, 2006. 248 pp., $40.

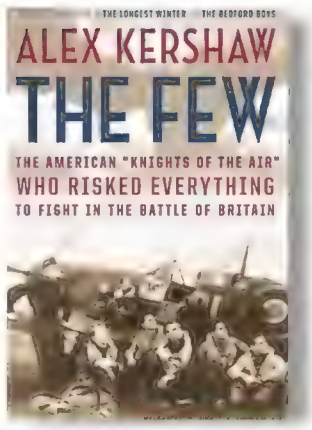
SPACEFLIGHT is a thrilling endeavor, given to elegant prose and stunning visuals. Making the most of this, David West Reynolds' *Kennedy Space Center: Gateway to Space* offers a meditation on the excitement of reaching for the stars. Since 1950, what is now the Kennedy Space Center (Cape Canaveral was renamed in 1963 after John F. Kennedy's assassination), located in central Florida along the Atlantic Ocean, has served as the nation's spaceport, and Reynolds tells the story for a general audience, using incisive text and more than 150 images.

The book, organized chronologically, discusses Kennedy Space Center's origins, its space launch operations, the various human flights, and the more recent space shuttle and International Space Station missions. One chapter, which details a shuttle's preparation for launch, is especially informative.

Reynolds also discusses the tragedies of Apollo 1 (1967), *Challenger* (1986), and *Columbia* (2003), condemning the "penny-wise, pound-foolish" decisions of NASA that contributed to them. Finally, he looks into the future, discussing private spaceflight and KSC's efforts in the 21st century.

The book is a fine introduction to the history of the Kennedy Space Center, bringing to a wider audience the insights of many who have written about space, including myself, and telling an important story.

ROGER D. LAUNIUS IS CHAIRMAN OF THE NATIONAL AIR AND SPACE MUSEUM'S DEPARTMENT OF SPACE HISTORY.



The Few: The American "Knights of the Air" Who Risked Everything to Fight in the Battle of Britain

by Alex Kershaw. Da Capo Press, 2006. 284 pp., $25.

REVIEWING A NON-FICTION history book written in a narrative fashion is like assessing an enemy aircraft before meeting it in combat. You run down a list of probable drawbacks and pitfalls, looking for a weakness to exploit. Does the book sacrifice veracity for drama? The "forgotten tales of unknown heroes": Are the tales truly forgotten? Are the heroes significant figures or sideshows?

In the case of *The Few*, Alex Kershaw's book about U.S. pilots fighting in the Battle of Britain, a reviewer has to go pretty far down the list to find valid complaints. Here they are: In some dogfight sequences, the author uses distracting non-words—*Powp!*—to describe the sounds of cannon and bullet impacts. And running a list of characters that states who died—and when—just before the prologue ruins some of the drama that follows.

That's it for gripes. The adventures of the handful of known pilots who volunteered to help Britain before the United States entered the war are recounted in depth and with great humanity. The book hums along, telling richly detailed stories, from the pilots' Atlantic crossing to their wartime careers. With the exception of Winston Churchill, most famous figures are ignored. That's fine; they are not needed. It's the fliers who are central to the plot.

The pilots themselves are all eager and ambitious, yet each is engagingly distinct. They come alive on the page, making the experience of sharing their adventure wholly satisfying—and eventually sad, as the war claims them, one by one.

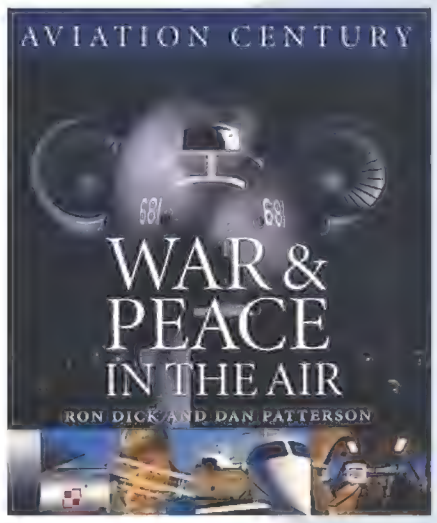
JOE PAPPALARDO IS AN ASSOCIATE EDITOR AT *AIR & SPACE/SMITHSONIAN*.

>>> At a Glance <<<

Saturn: A New View

by L. Lovett, J. Horvath, and J. Cuzzi. Abrams, 2006. 191 pp., $40.

YOU NEEDN'T CARE ONE WHIT about planetary science to appreciate the artful images in this book; the 150 high-resolution photographs, taken by the Cassini spacecraft and the Huygens probe, show without a doubt that Saturn is a many-splendored thing.



War & Peace in the Air

by Ron Dick and Dan Patterson. Boston Mills Press, 2006. 352 pp., $49.95.

THE FIFTH AND FINAL VOLUME in the Aviation Century series by Ron Dick (an *Air & Space/Smithsonian* contributing editor) and photographer Dan Patterson chronicles aircraft development from the early Jet Age to the present.

F-117 Nighthawk Stealth Fighter: Photo Scrapbook

by Yancy D. Mailes and Tony R. Landis. Specialty Press, 2006. 108 pp., $16.95.

EVER WONDER WHAT the Lockheed F-117 stealth fighter looks like painted in the colors and markings of the U.S. flag? This book has that image and hundreds of others in a photo essay documenting the F-117's history, beginning with its stint as a Skunk Works mockup and continuing to the aircraft's acceptance by the U.S. Air Force.

Air to Air Warbirds

Photographs by Paul Bowen. $14.95.

Legacy of Speed

Photographs of air racing. $15. Available at *www.legacycalendars.com*.

Air Power

Photographs from CheckSix. $14.95.

TIME FLIES

Calendar Roundup

The new year looks to be a very good one for aviation calendars, especially if you fancy military aircraft, old and new. From World War I's Fokker triplane to the U.S. Navy's F/A-18E/F Super Hornet, the hottest combat airplanes looking their best illustrate these calendars. All calendars except *Legacy of Speed* are available at *www.historicaviation.com*, or phone (800) 225-5575.

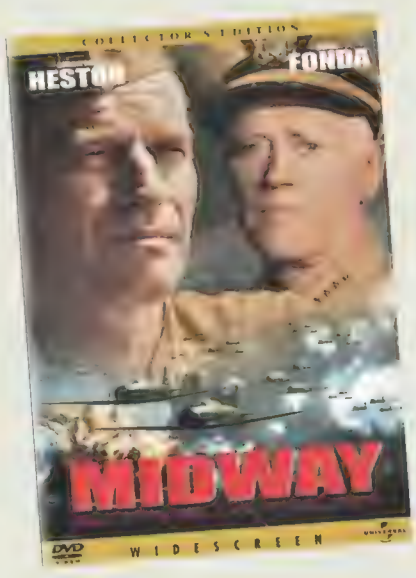
Flying Legends

Photographs by John Dibbs. $14.95.

Ghosts of the Great War

Photographs by Philip Makanna. $14.95.

>>> Out of the Vault <<<



Midway (Collector's Edition), DVD. Rated PG. Universal Studios, 2001. $14.98.

ORIGINALLY RELEASED IN 1976, *Midway* played in theaters equipped with Sensurround, a technology that blasted moviegoers with high-decibel sound during the film's many aerial battle scenes, which depict the Japanese navy's attempt to mount a surprise takeover of the U.S. Navy base on Midway Island in 1942. Although the cast is large and includes many notable actors, such as Charlton Heston and Henry Fonda, the strength of the movie is its depiction of the cat-and-mouse game between Japanese Admiral Isoroku Yamamoto and American Admiral Chester W. Nimitz: Without the advantage of today's reconnaissance satellites, each man did his best to determine the position of the enemy fleet in the Pacific. Aviation buffs will appreciate the inclusion of actual carrier battle footage from the Navy's archives, interspersed among scenes filmed aboard the USS *Lexington*. The Collector's Edition features still photographs and interviews with the producer, director, and Heston.

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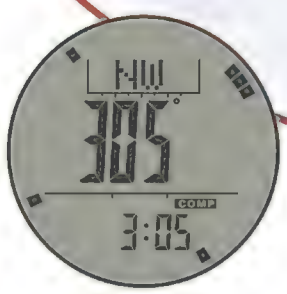
XG-55



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No More New Orleans Cover-up

WHEN HURRICANE KATRINA battered New Orleans on August 29, 2005, the winds and rain also ravaged one of the nation's last Art Deco airports—Lakefront Airport, on the southern bank of Lake Pontchartrain. But there's a silver lining to the storm clouds.

Opened on February 9, 1934, as Shushan Airport, after Levee Board president Abraham Shushan, the general aviation field is home to the oldest Art Deco air terminal complex in continuous operation in the United States. One of its more notable visitors was Amelia Earhart, who flew in with her Lockheed Electra 10E on May 22, 1937, on the second overnight stop of her ill-fated flight around the world.

The sculptural relief on the terminal's façade traces the progress of aviation and its influence on society.

UNIVERSITY OF NEW ORLEANS, LOUISIANA COLLECTION, SHUSHAN COLLECTION

GERRY MATRANGA

Renamed "Lakefront" in the 1940s, the airport terminal was converted to a bomb shelter-like structure in 1964.

Katrina's visit, by contrast, brought misery. The city's breached levees flooded Lakefront with eight feet of water outside the terminal and four feet inside. Wind and water wrenched window frames from walls and tore doors from hinges. It took until February 12, 2006, to get Lakefront fully operational again, although the number of takeoffs and landings now—about 3,000 a month—is just one-third as many as before the storm.

It wasn't Katrina, however, that stripped Lakefront of its Art Deco charm. Blame that on a 1964 conversion of the building into dual-use terminal and fallout shelter. "They wrapped it in concrete panels and made it into this big, monolithic block," explains Randy Taylor, the airport director. "It had no redeeming grace. Even the architect said he ruined it."

Now for that silver lining. "The panels that Katrina confronted are gone. They just broke off or got ripped away," says Taylor. The plan is to remove the rest by December, evaluate the condition of the building, and—with insurance funds and possibly historic grants—restore Lakefront to its former glory. The terminal's interior retains its original touch, with frescoes, marble staircases, and unique aviation murals. If Taylor has his way, the exterior will soon match. "I'd like to see it restored," he says. "Right now, it's just a big ugly eyesore."

VINCENT P. CAIRE

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>>> Calendar <<<

December 1, 8, 15, & 22
Behind-the-Scenes Tour. Take a guided tour of the National Museum of the U.S. Air Force's restoration hangars, located on the historic Wright Field flight line. Wright-Patterson Air Force Base, OH. Tours start at noon; to register, call (937) 255-3286, ext. 302, or visit *www.nationalmuseum.af.mil*.

December 2
Seminar: Zero Fighters Over China. Weather permitting, the museum's Zero will make a demonstration flight. 10 a.m. to 2 p.m. Planes of Fame Museum, Cal-Aero Field, Chino, CA, (909) 597-3722, *www.planesoffame.org*.

December 7
Reading. Author Andrew Carroll will read from his latest book, *Operation Homecoming: Iraq, Afghanistan, and the Home Front in the Words of the U.S. Troops and Their Families*, an anthology of letters and poems written by U.S. military personnel and their families. 6 to 8 p.m. Museum of Flight, Seattle, WA, (206) 764-5720, *www.museumofflight.org*.

December 9
Family Day. 10 a.m. to 3 p.m. National Museum of the U.S. Air Force, Wright-Patterson Air Force Base, OH, (937) 255-8048, ext. 462, *www.nationalmuseum.af.mil*.

January 1
Blackbird Tip-to-Tail Tour. Still the world's fastest piloted jet, the Lockheed SR-71 Blackbird reconnaissance airplane continues to amaze more than four decades after its first flights; docents will lecture on the museum's M/D-21 version. 11 a.m. to noon and 2 to 3 p.m. Museum of Flight, Seattle, WA, (206) 764-5720, *www.museumofflight.org*.

Organizations wishing to have events published in Calendar should fax press releases to (202) 275-1886; e-mail them to *editors@si.edu*; or mail them to Calendar, *Air & Space/Smithsonian*, MRC 951, PO Box 37012, Washington, DC 20013-7012.

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**Source: "Lighting the Way to Energy Savings"; 1999

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Its 27-watt compact bulb is the equivalent to a 150-watt ordinary light bulb. This makes it perfect for activities such as reading, writing, sewing, needlepoint, and especially for aging eyes.

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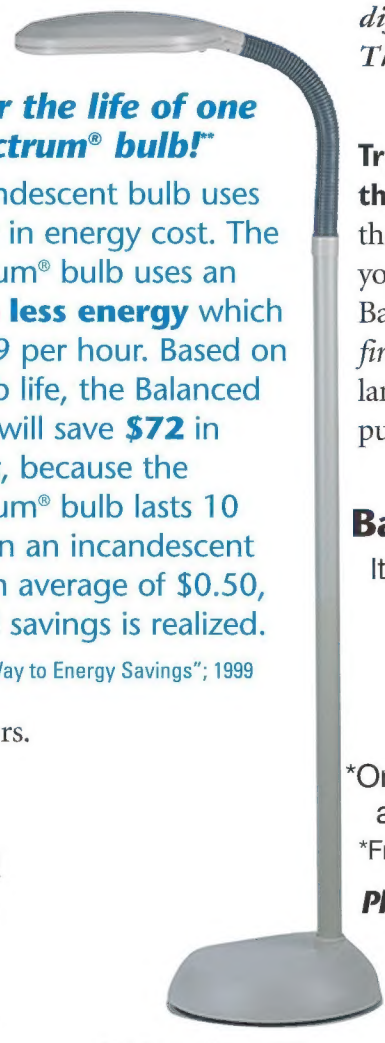

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(Signed) Thomas Ott
President & Publisher
Smithsonian Magazine Group

>>> Credits <<<

Sea Legs for the Super Hornet. Frank Morley went on to become commanding officer of an F/A-18 squadron.

The Pi-Balls of My Youth. Jeanne Prevett Sable is a writer, a gardener, and the author of *Seed Keepers of Crescentville* (Booklocker, 2005).

The Physics of Winning. George C. Larson is a senior editor at *Business & Commercial Aviation* and a diehard air racing fan.

Restoration: Lake Murray's Mitchell. Kay Gordon is a journalist who worked for the *State-Columbia Record* in South Carolina for nearly 20 years.

Mystery on Guadalcanal. Ralph Wetterhahn is the author of *Last Flight of Bomber 31* (Carroll & Graf, 2004).

How Things Work: Electromagnetic Catapults. Tim Wright is a freelance writer and photographer.

Build This Airplane for 10 Grand. Bettina H. Chavanne is an associate editor at *Air & Space/Smithsonian*.

Moonbound. Tony Reichhardt is a senior editor at *Air & Space*.

475,000 Takeoffs and Landings a Year. Michael Milstein is a frequent contributor.

Extreme Airshow. Debbie Gary flies airshows, writes stories, and lives in an airpark in Texas. In 2001 and 2002, she and Carol Pilon flew several all-woman wingwalking shows in Jimmy Franklin's other black Waco, *Mystery Ship*.

The Thin Aluminum Line. Longtime contributor Carl Posey writes from his home in Alexandria, Virginia.

No More New Orleans Cover-up. Vincent P. Caire, a documentary filmmaker specializing in the history and culture of Louisiana, got his private pilot license at New Orleans' Lakefront Airport.

DON PARSONS

<< The Airplane That Nobody Heard Of

Born during the post-Lindbergh boom in a short-lived aircraft factory, this Zenith is the survivor from a litter of seven. No wonder so few recognize it.

The enigmatic Zenith Z6A was restored last year at a small airport near St. Louis.

Last One Flying

The last Grumman F4F of 1,600 built and a Vertol H-21 helicopter are among our profiles of types facing extinction.

The First Chinese Astronaut

When Yang Liwei went into orbit in 2003, China not only gained a space program but a reluctant celebrity.

It's Not How You Play the Game. Win.

Wargaming expert James Dunnigan weighs in on the state of Air Force combat training simulations.

Space Craze

When did the theme of space travel first become a fad? (Hint: Long before the Hula Hoop.)

How to Hawk an Airplane

Vendors fight for a share of the small-aircraft market, one sales pitch at a time.

Custer Rides Again?

Researchers at the Georgia Institute of Technology try to resurrect the 1950s Custer Channel Wing to meet 21st century needs.

Faster, Higher, Farther

Enevoldson, Fossett, and the DG-505.

STEVE FOSSETT HAS MADE it his goal to fly and sail faster, higher, and farther than anyone else in the history of sport.

Now he has the world glider altitude record—50,671 feet—set on August 30 with copilot Einar Enevoldson over the towering spine of the Andes Mountains near El Calafate, Argentina. The objective of the flight, a goal Fossett has been pursuing on three continents and for five seasons since 2002, was to demonstrate that an unpowered aircraft and its crew could achieve stratospheric altitudes solely by artfully surfing the mountain wave that forms a powerful, invisible elevator.

The pair achieved the record altitude in a modified DG-505 Open Class two-seater named *Perlan*, after an Icelandic word for mother-of-pearl. (High-altitude ice clouds splinter sunlight into pearl-like colors.) The German-made sailplane, which has a 72-foot wingspan, was designed to be self-launching: It has an engine that deploys for takeoff, then stows itself after reaching altitude. By removing the launch engine, the team created an equipment bay in which to install oxygen tanks and batteries for the pressure suits and heaters needed at high altitudes, where the air is thin and temperatures can reach as low as –58 degrees Fahrenheit.

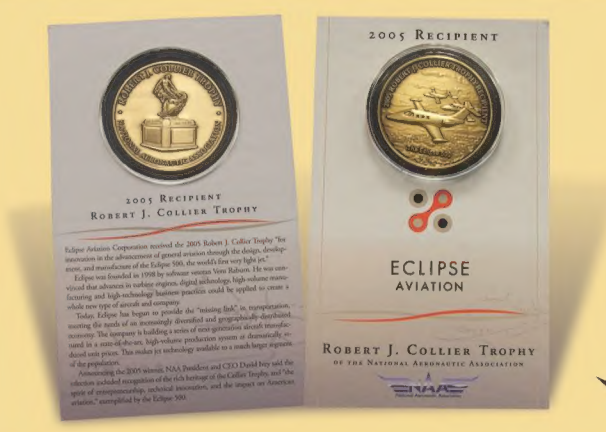
Their pressure suits, lent by NASA's Dryden Flight Research Center at Edwards Air Force Base in California, represented the team's appreciation for an important fact: Many pilots attempting altitude record flights had come back with brain damage from the lack of oxygen in the low-pressure atmosphere. Says Cam Martin, a Dryden spokesman with extensive soaring experience: "It's the equivalent of giving yourself a stroke."

The two fliers would take four and a half hours to top out at the new record altitude, and would spend most of that time seeking the mountain wave that creates the lift they would need. The pair were also dealing with the aerodynamic "coffin corner" that U-2 pilots encounter as they climb to an altitude where the wing's stall speed and its critical Mach number converge. At this point, the slightest pitch down will exceed the aircraft's Mach limit and the slightest pitch up will cause a stall.

The two never flew more than about 60 miles from their takeoff point at El Calafate, but then the point was not to go far but to go up. Far can wait for another day.

GEORGE C. LARSON, MEMBER, NAA

>>> Logbook <<<



The Centennial Medallion

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